

Building Construction and Meaning: The Origin and the Occupation of Chinese *Tingtang*

Pengfei Ma
University of New South Wales

Abstract

*This paper attempts to answer two questions: what was the essential technological feature of Chinese timber structure, and how did it accommodate unique Chinese living? Timber structure, as the dominant traditional structural system, had a long-lasting impact on the entire built environment of pre-modern Chinese history, as well as on that of East Asia and beyond. Although the origin of Chinese timber structure can be traced back to pre-historic times, material describing the technical characteristics of China's timber structural system are very scarce, especially against the background of the vast amount of ancient literature in China. Even in the comprehensive document explaining the Northern Song building standards, *Yingzao-fashi* (营造法式 *State Building Standards*), commissioned by the imperial court in 1103 C.E., there was no elaboration on the technical nature and functions of the structural systems installed at the time. However, such knowledge must have been in demand in building practice and shared as widely accepted rules by designers and builders, albeit tacitly. Focusing on a specific structural type, *Tingtang* (厅堂 hall), this paper explores the features of timber framework based on the unique architectural expression of *Yingzao-fashi*. The relationship between building types and structural types is then examined through a historical review of the building forms *Ting* (厅) and *Tang* (堂). Finally, this research will discuss how parallel space, as the basic spatial form of Chinese architecture, services various urban buildings and living demands.*

Timber Framework in *Yingzao-fashi*

Load-bearing timber framework, a network of interlocking wooden supports forming the skeleton of the building, is considered China's major contribution to architectural technology. For several thousand years timber framework was consistently the dominant structural form of buildings in pre-modern China as well as East Asia, regardless of function and size. Despite its dominant position, very little Chinese

literature considers detailed structural features and construction standards until the Northern Song period (960-1127C.E.). Northern Song dynasty was one of the cultural peaks of pre-modern China, especially in aspects of art and literature, although it has been the smallest regarding land area among all the united empires that established on the vast Central Plains. Its reign extended to the south-eastern coast of China, but in the north, it merely occupied some part of Hebei, Shanxi, Shaanxi and Gansu provinces compared with current geopolitical boundaries of today China. Northern Song dynasty was also an era of administrative sophistication and complex social organisation, leading to disordered management of construction activities. To standardise the state-run construction, a state building standard was enacted by the contemporary central government.

Yingzao-fashi (营造法式 State Building Standard), published by the Northern Song court in 1103 C.E., was an enforceable building standard manual issued for official construction of the entire empire including palaces, religious and office buildings as well as official dwellings. It was compiled by Li Jie 李诫, an imperial superintendent of the Department of Construction. The 1078-page work, consisting of 357 chapters and 3555 clauses, regulated construction procedures, modular systems, and the allocation of materials and labour in official construction lunched and organised by the governments, central or regional. To standardise construction and make the regulations practicable, it also listed the typical patterns of various building components and structures, which made it a technical reference as well. *Yingzao-fashi* was a seminal architectural work influencing the contemporary and following construction and architectural development in urban China.

Yingzao-fashi described two major structural types within its text: *Diange* (殿阁 palace) and *Tingtang* (厅堂 hall) and presented many typical patterns of them with illustrations attached.¹ Surprisingly, even this classic architectural work did not elaborate on the technical characteristics, classification, and functions of the timber structural systems. However, Chinese designers and builders must have tacitly understood the features and scope of these structural types, since familiarity with them was in demand in building practice. A possible explanation is that structure selection benefitted from the subconscious knowledge of the construction participants who had both experience and the explicit building instructions firmly in mind. Due to the lack of historical records, we can only guess at the likely process adopted by the construction sector to achieve the structurally sound design.

The formal features of the *Diange* and *Tingtang* can be summarized through illustrations of *Yingzao-fashi*. The magnificent buildings of royalty or divinity, such as halls of the palaces and temples, were normally built in a *Diange* framework, which lent them an air of nobility. *Yingzao-fashi* depicted the typical patterns of the *Diange* framework using illustrations called *dipan* (地盘 floor plan) and *ceyang* (侧样 side

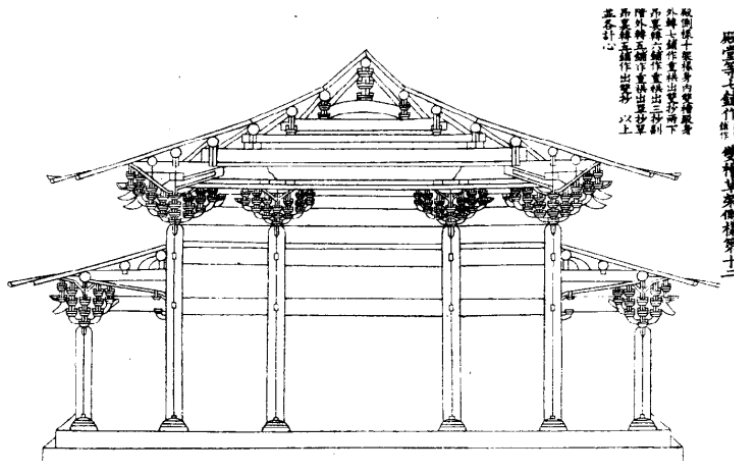


Figure 1. A *Ceyang* illustration of the *Diange* framework (Li Jie, *Yingzao-fashi*, 31 vols, [Beijing: The Commercial Press, 1954], 6).

sample), roughly equivalent to the plan and transverse section of modern architectural drawing respectively (Figure 1).² As the *ceyang* indicates, the *Diange* columns were all at the same height with a set of complicated brackets on each column head. The lowest beam rested on eave and column brackets and ran the full transverse distance. The ceiling was placed under the lowest beam and covered the whole rectangular plan, which enclosed a perfect cuboid space with columns. In contrast to *Diange*, *Tingtang* in *Yingzao-fashi* was introduced by a specific illustration of a transverse timber frame (Figure 2). That image embodied the basic characteristics of *Tingtang*. Columns increase in height from the exterior to the interior and beams are connected at one end to the top of the lower column with the other end inserted into the body of the higher column. There were no ceilings and no beams across the whole transverse dimension in *Tingtang* framework.

Although the *Tingtang* structure is clearly distinguished from *Diange* in the illustrations, the essential distinction between them has been one of the core topics in current scholarship on the structures of *Yingzao-fashi*, largely presented by Chinese scholars. Researchers suggest the prototype of the *Diange* framework may have been a clay-timber building *Tai* (台 terrace), prevalent in the first millennium B.C.E. of China.³ On the other hand, the *Tingtang* framework maintained a close relationship with the *Chuandou* (穿斗 through tenon) construction, a structural form applied widely within the vernacular dwelling houses of South China.⁴ In particular, modern scholar Zhang Shiqing 张十庆 re-classified the structural types of Chinese architecture based on different modes of tectonic thinking and further elaborates the technical features of *Diange* and *Tingtang*. According to his research, *Diange* represented a form produced through the accumulation of building elements vertically, while *Tingtang* referred to a

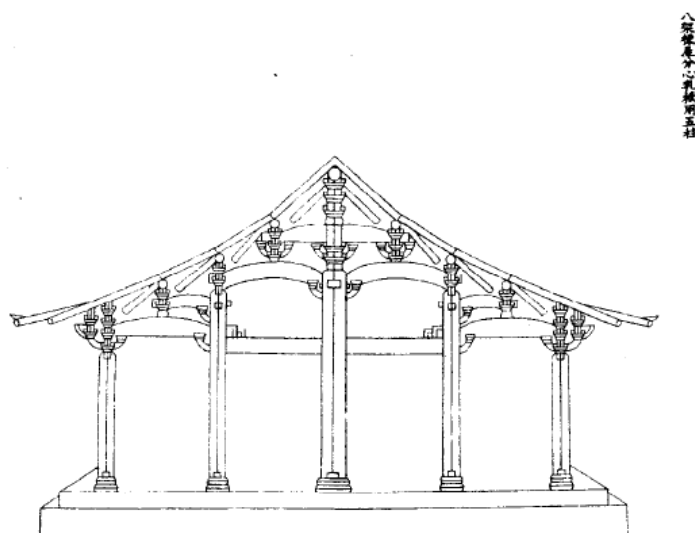


Figure 2. A sample of the transverse frame of *Tingtang* (Li Jie, *Yingzao-fashi*, 31 vols, [Beijing: The Commercial Press, 1954], 11).

structure formed by securing transverse timber frames using purlins and lintels longitudinally (Figure 3).⁵ As for both *Diange* and *Tingtang*, the structures were enclosed by brick or clay walls of what is now called curtain walls, ensuring the structures remains strong against wind and possibly seismic loads. The south wall was usually the only one with windows and entrances. *Diange* and *Tingtang*, as distinct construction tactics, essentially represent two original ways of tectonic thinking about shaping a timber structure and ensuring that it was durable.

Yingzao-fashi is the oldest extant work of literature on Chinese architecture, and modern scholars treat it as a key reference in understanding Chinese construction in a period of great prosperity. Though *Yingzao-fashi* was early introduced to the West

around the 1920s, research on the publication beyond China, especially regarding timber structure types, has been limited over the last three decades.⁶ A reason for this deficiency is that *Yingzao-fashi* has not been translated into a western language, but over the past decade, Chinese academia has enthusiastically embarked on studying the structural system recorded in this treatise. Chinese researchers have devoted much attention to the text and illustrations of *Yingzao-fashi* and contributed to the interpretation of technical terms and formal features of the structures. Uncovering the technical legitimacy of these structures is the primary goal of these researchers. However, the relationship between timber structures, contemporaneous technology, and Chinese modes of life in both family and society, has attracted little attention among scholars.

The *Tingtang* Structure and Architectural Expression

Yingzao-fashi offers eighteen illustrations in its attachment of exemplars of the *Tingtang* framework, all named as ‘the beams and columns between two bays’. If we see these illustrations as drawings of transverse sections of the whole structure, similar to *Ceyang*, it is noteworthy that, compared to *Diange*, *Yingzao-fashi* failed to list any *dipan* (floor plan) for *Tingtang*. From a modern architectural viewpoint, it is impossible to identify a structure only with a section or elevation. How did the Chinese builders achieve this? It is probably because that illustration was not merely a kind of elevation or section drawing (which derives from modern architectural expression) but a specific diagram, accepted by builders and artisans at that time, intended to identify the entire structure. Such a diagram reflected the essential feature of the *Tingtang* framework.

A building with a *Tingtang* framework, in essence, was produced by the longitudinal connection of transverse frames. The space between two single timber frames, called *Jian* (间 bay), was normally used as a unit to estimate the building scale in China. The width of a building in the *Tingtang* framework normally depended on the number of bays, which was indicated through the front facade, the main visual focus of a Chinese building. In this case, builders and common people preferred to describe the general scale of a Chinese building by the number of bays provided, for example “a 5-bay building (五间房)”. Meanwhile, building depth and height were established by the dimension of the transverse frames crossing the plan. (Figure 3). Once the designer and builder confirmed how many bays the building would be and what type of transverse frame would be adopted, the massing of the whole structure would be set up in three-dimensions. There was no need to consider the plan layout since this had already been determined by the number of bays and the position of the transverse

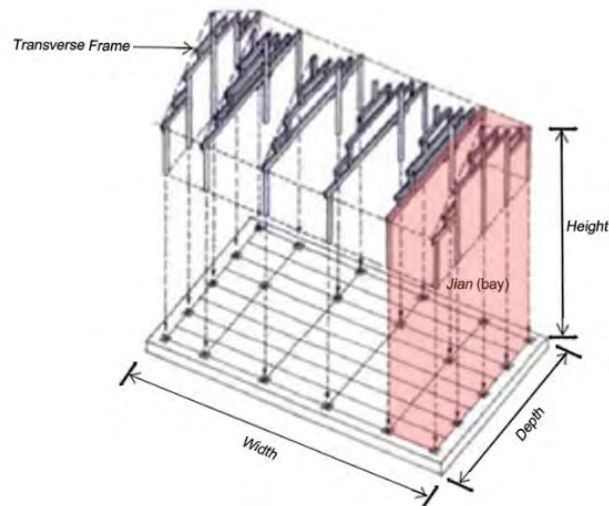


Figure 3. Composition of the *Tingtang* framework
(Drafted by Pengfei Ma).

frames. That explains why *Yingzao-fashi* only offered an image of transverse frames to demonstrate “the beams and columns between two bays”. This kind of expression fully matched the *Tingtang* framework and was likely to be the most rational way to guide construction. Because, at a technical level, construction practitioners only needed to refer to the types of transverse frames already depicted in the *Yingzao-fashi* illustrations if they understood the scale and function of the structure they intended to build.

Yet, how did builders understand the scale and function of a building within *Tingtang* style before construction? In imperial China, this was never a subject that builders needed to consider, for imperial laws provided rigorous regulations for the scale and style of various buildings based on the hierarchy of the empire. For instance, in the Tang and Song dynasties, there were nine grades of officials, and diverse regulations were issued to define the building form and scale of offices and dwellings for officials in different grades. *Tang Huiyao* (唐会要 the historical records of the national regulatory framework of the *Tang* dynasty) provided for the relevant clauses of *Yingshanling* (营缮令 the law of construction and repair) in Tang dynasty:

The width of mansion buildings for officials above fifth grade was not allowed to be over five bays, and that for officials under sixth grade was not allowed to be over three bays ”⁷.

The law of construction and repair prevailing in the subsequent Song dynasty followed these Tang dynasty provisions without any change.

Yingzao-fashi, as the imperial building standard of the Song dynasty also prescribes the scope of *Tingtang* technically. The standard uses *Caifen* (材分), a modular system for all dimensional measurements in structural carpentry, to control the proportion of the overall building and its major components. *Caifen* presented a set of basic units ranging from high grade to low reflecting the size and importance of corresponding buildings. Each is a combinational dimension of length and width for the rectangular cross-section of an eave bracket component *Huagong* (华拱). That dimension is the basic modular unit. All dimensions in the carpentry of the structure relate to the basic unit, thus controlling overall dimensions and proportion of the structure.

Eight grades for the basic units were applied to the buildings in different classes representing different occupants in the Song dynasty. Given the text of *Yingzao-fashi*, the basic units of the first and second grade were used for important palace or temple halls of royalty and divinity. Normally they had eleven, nine or seven bays, while the basic units from the third to seventh grade were for official mansions or ordinary official buildings with seven, five or three bays. The *Tingtang* framework was the structural type used only for buildings with basic units from the third to seventh grade, whereas structures with basic units of the first and second grade had to be built with the *Diange* framework.

Following these explicit regulations for building function and scale, builders could identify a *Tingtang* structure easily under the guidance of *Yingzao-fashi*. *Tingtang*, if less important than *Diange*, had wider applicability and flexibility to satisfy the varying needs of living, both for society and family. Throughout the Song dynasty and subsequently, *Tingtang* was broadly adopted as the major structural form of urban buildings, especially offices and official dwellings. Indeed, the name *Tingtang* expresses its two inherent building types, each assuming significant roles in Chinese pre-modern habitation: *Ting* and *Tang*.

Ting and Tang

Due to the dearth of knowledge of the roots of Chinese architecture, the Chinese architectural concepts *Ting* and *Tang* have generally both been rendered as “hall” or “mansion” in most English literature referring to them, thereby losing the unique and

specific original meanings. The introductory chapter of *Yingzao-fashi* discussed the meaning of *Tang* by quoting ancient documents, *Shuowe* (说文 explaining characters) and *Shiming* (释名 interpreting names), but these interpretations for *Tang* were too simple to illustrate the profound meaning of *Tang* within Chinese culture.⁸ *Yingzao-fashi* did not offer any interpretation for *Ting*, while some other contemporary literature did.⁹ The original semantic meaning of the Chinese word *Ting* was listening; it later became an architectural concept when referring to a one-storey building for administrative officials to handle governmental affairs

The earliest architectural mention of *Tang* dates back to the Zhou dynasty (1044-256 B.C.E.). The Chinese classic text about social behaviour and ceremonial ritual in Zhou dynasty, *Yili* (仪礼 etiquette and ceremony), presented two meanings of *Tang* at that

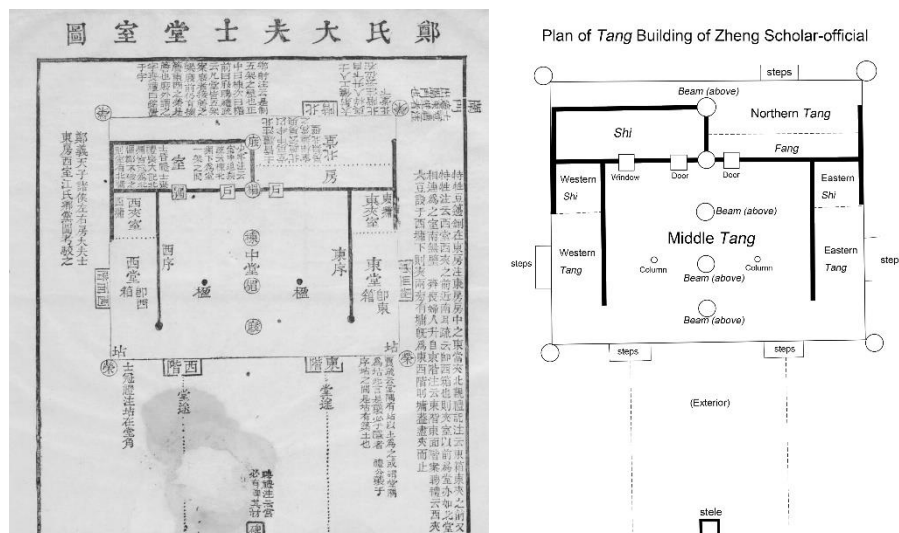


Figure 4. Internal layout of a Tang building of scholar-officials during Zhou dynasty from *Liyitu* (礼仪图, Etiquette) by Zhang Huiyan in Qing dynasty, English translation by Pengfei Ma (National Diet Library, Tokyo).

time. First, the main structure of a building complex either for official residences or public activities, like temples and schools, was called *Tang*. Specifically, the *Tang* building in the plan was normally divided into two sections: the front was an open space, and the rear consisted of enclosed spaces known as *Shi* (室 bedroom) and *Fang* (房 ordinary room) for living and storage respectively (Figure 4). Apart from being the name given to the whole building, *Tang*, secondly, was also the name of the open space front section, and there could be more than one *Tang* space in a *Tang* building. The open space of *Tang* in dwellings was for private conversation and important family rites like weddings and funerals, while for public institutions it functioned as a common meeting

area and for ceremonies. In the following Han dynasty, the configuration of the *Tang* building for official dwellings remained as that in the earlier Zhou dynasty, but some senior officials and nobilities started to build another independent *Tang* building as a place to handle their official business. This was called exterior *Tang* and possessed the same spatial configuration as the original interior *Tang* for family living. The two *Tang* buildings in one dwelling were separated by a door, *Zhongmeng* (中门 middle gate) to form two yards front and back.

Ting as an architectural type emerged much later than *Tang* and assumed a different role from *Tang* in Chinese habitation. According to the historical literature of the Weijin period (220-420C.E.) *Ting* was not only the office building for administrative officials to handle governmental affairs but also the main building of some officials' dwellings. For instance, the *Weishu* (魏书 historical record of the Wei dynasty) describes a *Ting* building well-known in Taiyuan county. It was built by Wang Chun 王椿, the local governor famous for his professional skills in construction, and his *Ting* building functioned as the main structure of his mansion. Residents were so impressed by the grandeur of the structure that they called Chun's mansion 'the King' mansion of *Taiyuan*.¹⁰

From the Tang dynasty (618-907 C.E.) forward, the residential and office buildings of incumbent officials tended to merge into cases known as *Yazhai* (衙宅 office dwelling). Though *Yazhai* was a combined building complex, its settings for working and living incorporated separate courtyards linked only by doors. Some records of the historical literature of the time, for example, a story from *Jiu Tangshu* (旧唐书 the early historical record of the Tang dynasty) is evidence of the separation:

The senior general Gao Xianzhi 高仙芝 as well as the governor of *Anxi* district, often nominated his assistant general Feng Changqing 封常清 to govern and defend their administrative region when he went out to battle. Another general, Zheng Dequan 郑德詮, the son of Xianzhi's foster-nurse, maintained brotherly relationships with Xianzhi. Therefore, Dequan regarded Changqing as his servant and usually despised him. Once, when Changqing returned to the government office, following the lead of other generals, Dequan rode a horse in front of them in order to show contempt for Changqing. When Changqing arrived at the *Ting* of the government office, he immediately ordered his men to bring Dequan, who was in the governor

Xianzhi's dwelling at that time, to see him clandestinely. The *Ting* building (where Changqing arrived) was connected to the dwelling courtyards. After Dequan went through several doors and reached the *Ting*, Changqing ordered his men to close these doors, isolating the *Ting* from the dwelling courtyards.¹¹

In addition, the clauses of the Tang dynasty *Yingshanling* (营缮令 the law of construction and repair), specific to the official dwellings, only stipulated the rules for the construction of *Tang* and lacked instructions for *Ting*. That means *Ting* was not adopted as the building of official dwellings, indicating the rigorous distinction between offices and dwellings in the Tang dynasty. Also, there is insufficient evidence to confirm that *Ting* had been a building for dwellings of common people at that time.

Ting came to be recorded as a building serving common family living from the following Song dynasty (960 - 1279 C.E.). *Ting*, at that time, was not only built within official *Yazhai* but also within common people's dwellings. *Simashi Shuyi* (司马氏书仪 ceremonial of *Sima*) and *Zhuzi Jiali* (朱子家礼 family etiquette of *Zhuzi*) are two classics of family etiquette and ceremony, compiled respectively by the well-known Confucian scholars of the Song dynasty, Sima Guang 司马光 and Zhu Xi 朱熹. Both books specify the ideal configuration of Chinese resident courtyards.¹² The main buildings are positioned along the middle axis of the courtyards. From external to internal, in order are the entrance gate, *Ting*, middle gate, middle *Tang* and the bedroom. The order is quite similar to that found in the Han dynasty mentioned above, but a *Ting* building displaced the exterior *Tang* building of Han. For office dwellings, some local chronicles of the Song dynasty presented more a detailed configuration of *Yazhai* through illustrations (Figure 5). There was only one main *Ting* located in the central front yard, connected to the rear *Tang* buildings by corridors, while there could be several *Tang* buildings at the back and side yards. Doors or corridors were used to link the *Ting* and the courtyard walls on both sides. Because of the requirements of etiquette, *Ting* was the main building, functioning as a meeting room for guests or officials and handling

government business. In contrast, *Tang* at the rear was mixed with gardens and living rooms to support private family conversation and daily leisure.

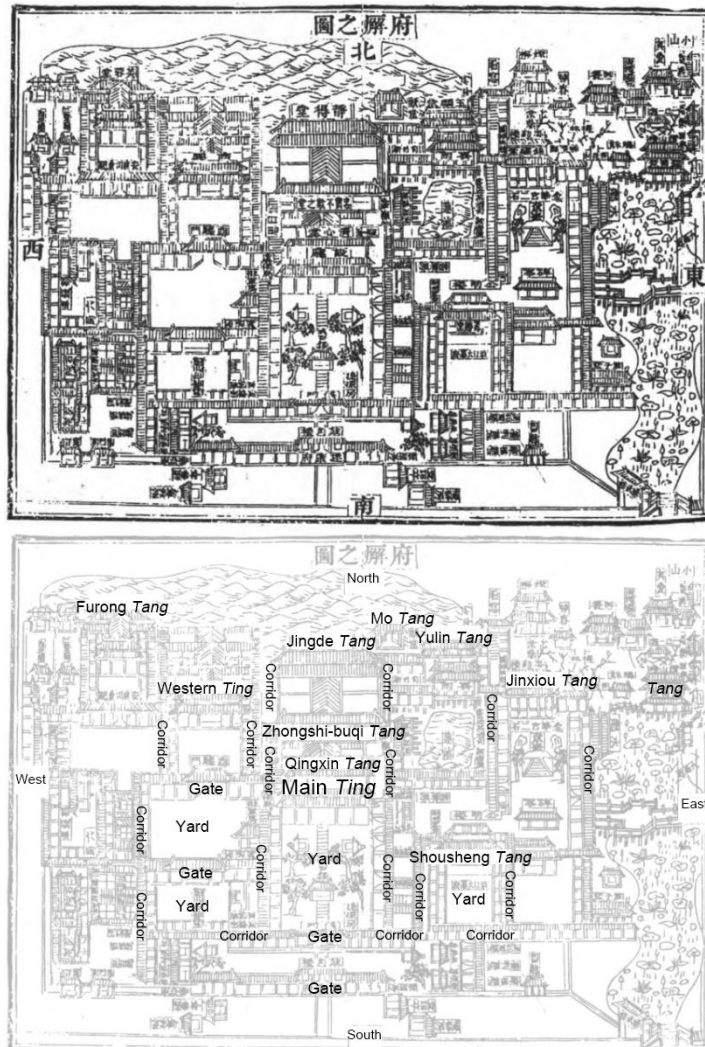


Figure 5. Plan of a Song *Yazhai* from *Jingding-Jiankangzhi* (景定建康志 local chronicle of Jiankang), by Zhou Yinghe in the Southern Song dynasty, English translation by Pengfei Ma (Guo Daiheng, *The Ancient Chinese Architectural History*, 3 vols, [Beijing: China Building Industry Press, 2003], 616).

Overall, *Ting* and *Tang*, albeit a close nexus in Chinese dwellings, were two building types for different functions until the Song dynasty. *Ting* was mainly the building for social communication and government business, while *Tang* accommodated family living and rituals. In naming the timber framework *Tingtang*, the compiler of *Yingzao-fashi* seemingly attempted to establish a corresponding relationship between building types and structural types, notwithstanding not presented as a strict regulation. As a state standard for official construction, the treatise failed to standardise vernacular dwellings, but the *Tingtang* framework was also widely applied in the building *Ting* and

Tang of common people with strict limitation for the use of eave brackets and the number of *Jian* (间 bay) of their buildings. In fact, *Ting* and *Tang* of both officials and common people gradually merged into one building to carry both society and clan living during the following Ming dynasty (1368-1644 C.E.) and Qing dynasty (1644-1912 C.E.). As the core buildings of Chinese dwellings and government offices, *Ting* and *Tang* were simply the architectural representatives of Chinese inhabitation. Hence, how did the structural type *Tingtang* bear such plentiful and complicated meanings that had been evolved for several thousand years?

Parallel Space and Chinese habitation

The unique spatial organisation of *Tingtang* fostered identifiably Chinese modes of life through the building of *Ting* and *Tang*. The timber structure was the cardinal element forming the space and volume of Chinese buildings, and to a large extent, determined their internal spatial configuration. The basic measuring unit of building scale, *Jian*, in *Tingtang* was fundamentally the space between two transverse frames. (Figure 3) The tectonic tactic underlying the *Tingtang* framework, the longitudinal connection of transverse frames, produced a series of homogeneous parallel spaces, or bays, defined by transverse frames. A typical Chinese *Ting* or *Tang* for common people was of three to five bays, while the significant buildings of royal palaces or temples could be of nine or eleven bays. Parallel spaces were the essence of the spatial features matching the specific functions of Chinese living.

However, it is evident that the simple parallel relationship was inadequate for accommodating the varied nature of Chinese living. Parallel spaces were of the same depth and height, and only their width could fluctuate. These properties limited the utility of simple parallel spaces, but Chinese builders enriched their extension to make them sufficiently flexible. The combination, rotation, and conversion of parallel spaces, according to the practical demands of construction, were to enable much complex and subtle spatial configuration in Chinese buildings. In addition to single buildings, even the classical Chinese courtyard, the basic pattern of Chinese residence, may be considered a logical extension of *Tingtang*, for the peripheral buildings enclosing the courtyard were all with the *Tingtang* framework.

To illustrate with a case, *Sanshan Villa* (三山别业) was the dwelling of Lu You 陆游 (1125–1209) the preeminent poet of the Southern Song dynasty. The main living area was roughly located in a building in the centre of a large landscaped garden. The main building, with a plan in the form of \perp , was a typical set of parallel spaces (Figure 6). There was a five-bay structure placed in the front, while the bay in the middle was the *Tang* space. Three parallel bays were perpendicular to the front five parallel bays, connecting to the rear of the *Tang* space. According to Lu You's own writing, the three-

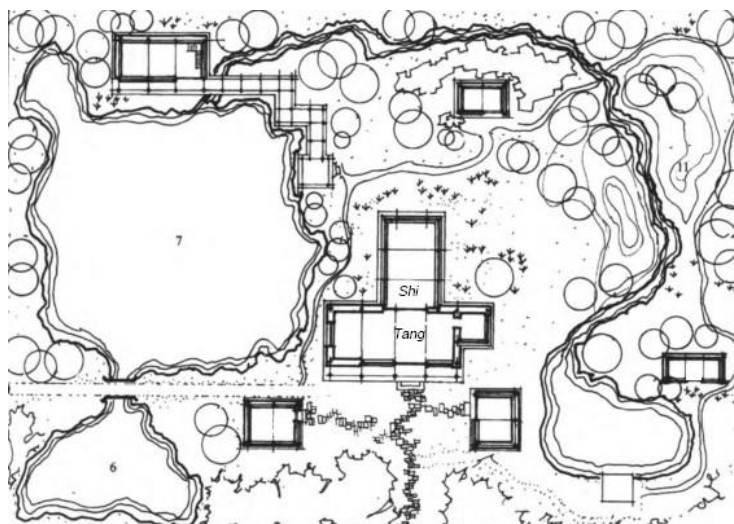


Figure 6. Plan of Sanshan Villa
(Guo Daiheng, *The Ancient Chinese Architectural History*,
3 vols, [Beijing: China Building Industry Press, 2003], 618).

bay structure linking to the *Tang* was the *Shi* (室 bedroom) for living and sleeping, while *Tang* was the place to meet for the purpose of a private conversation with guests.¹³ The door at the front facade of *Tang* was the main entrance door of the building, and another small door connected the *Tang* and *Shi* spaces. In winter, the small door would be the entrance door of the *Shi* and usually closed to keep the *Shi* warm, thus separating *Tang* and *Shi* into two independent spaces. In the hot summer, the small door would be removed to encourage ventilation from the main entrance door to penetrate throughout the entire *Tang* and *Shi*. In this case, the *Tang* would merge with *Shi* into an integrated space. A noteworthy room was the end space of the right-hand side of the five-bay space. Its front wall recessed some distance, making the room much smaller than the other rooms. The summer sunlight would be blocked by the side wall of the room to the left, so Lu You called the small room a fine place for a summer respite.¹⁴

The main building of the *Sanshan Villa* exemplifies the flexibility of the parallel spaces, but it was not a unique case. In fact, the plan forms of 丁, 上, and even 工 were pervasive in the Song dynasty. The painting *Qiangli-jiangshantu* (千里江山图 Thousand Miles of Rivers and Mountains), was a masterpiece work of Wang Ximeng 王孟希, one of the most renowned court painters of the Northern Song period. The various dwellings depicted in this painting reflected the versatility generated by the combination, rotation, and conversion of parallel spaces. Although there is no evidence to prove that the dwellings depicted were identical to those in reality, their basic layout and form probably approximate that of real dwellings.

A typical family building of the Ming dynasty, the main building in a Chinese courtyard, also embodied the classic of parallel spaces for Chinese living. Within the five-bay structure the centre room *Tang*, as the most important space, was the place for ancestor ritual and family conversation. The two rooms adjacent to *Tang* were for daily living and family recreation, while the outermost rooms were bedrooms, treated as the least important spaces. From the Ming dynasty forward, it is arguable that a rectangular courtyard enclosed by *Tingtang* structures started to become the dominant form of Chinese dwellings until modern China. A typical courtyard, the historical type of Chinese residence, was also a building complex of parallel spaces.

Conclusion

In *Tingtang* Chinese builders created a structural type, which was highly appropriate for meeting imperial construction standards and supporting diverse living demands. Throughout imperial history, *Ting* and *Tang* were the core buildings of Chinese dwellings and government offices and for organising daily family and social living. The parallel spaces produced by the *Tingtang* framework, which could be combined into several complex configurations, constituted the fundamental spatial form of Chinese dwellings, office buildings and courtyards. It is their flexibility that has endowed the timber structure with an incredible vitality which underpinned Chinese habitation for millennia.

Endnotes

¹ In enumerating structure types, some scholars claim that *Yingzao-fashi* discussed four types in its text, *Diange*, *Tingtang*, *Yuwu* (余屋 remaining room), and *Tingxie* (亭榭 pavilion), see Guo Qinghua, 'Yingzao Fashi: Twelfth-Century Chinese Building Manual', *Architectural History*, 41 vols (1998), 1-13. However, according to the recent study of Zhu Yongchun 朱永春, *Yuwu* was not a structure type; see Zhu Yongchun, 'Retrospection on *Diantang*, *Tingtang*

and Yuwu in *Yingza-fashi* (关于《营造法式》中殿堂、厅堂与余屋几个问题的思辨), *Architectural History* (建筑史), 2 (2016), 82-89. *Tingxie* was a simple type of structure for landscape, and there were few illustrations for it in *Yingzao-fashi*. In summary, the main structure types for common buildings were *Diange* and *Tingtang*.

² Distinct from modern plan drawings, *Dipan* more precisely performed as illustration to denote inner structural arrangements including the position of column brackets and beams.

³ Zhou Xueying 周学鹰, 'Study on building technology of the Terrace in the Han dynasty (汉代高台建筑技术研究)', *Archaeology and Cultural Relics* (考古与文物), 4 (2006), 71.

⁴ Zhang Shiqin 张十庆, 'Scrutinise the traditional structural types and their evolution from tectonic thinking (从建构思维看古代建筑结构类型与演化)', *Architect* (建筑师), 4 (2007), 170.

⁵ Zhang, 'Scrutinise the traditional structural types and their evolution from tectonic thinking', 168-171.

⁶ W. Perceval Yetts, "A Chinese Treatise on Architecture", *the Bulletin of the school of Oriental Studies*, 4 vols, No. 3 (London Institutions, 1927), 473-492, and Demieville Paul, "Che-yin Song Li Ming-tchong Ying tsao fa che (石印宋李明仲营造法式)", *Bulletin, Ecole Francaise d'Extreme Orient*, 25 vols, No. 1/2 (1925), 213-264.

⁷ Wang Bo 王溥 [Song], *Tanghuiyao* (唐会要), (Beijing: Zhonghua Book Company, 2017).

⁸ Li Jie 李诫 [Song], *Yingzao-fashi*, 1 vols, (Beijing: The Commercial Press, 1954).

⁹ Song Qi 宋祁 [Song], Zheng Jian 郑戩 [Song], Zhao Zhenduo 赵振铎 (eds.), *Ji Yun* (集韵), (Shanghai: Shanghai Lexicographical Publishing House, 2013).

¹⁰ Wei Shou 魏收 [Qi], *Wei Shu* 魏书, (Beijing: Zhonghua Book Company, 1997).

¹¹ Zhao Ying 赵莹 [Jin], *Jiu Tang Shu* 旧唐书, (Beijing: Zhonghua Book Company, 1975).

¹² Sima Guang 司马光 [Song], *Simashishuyi* (司马氏书仪), (Beijing: The Commercial Press, 1936), and Zhu Xi 朱熹 [Song], "jiali (家礼)", *Zhuzi-quanshu* (朱子全书), (Shanghai: Shanghai Guji Press and Hefei: Anhui Education Press, 2002).

¹³ Lu You 陆游 [Song], "Jushiji (居室记)", *Luyou-quanji-jiaozhu* (陆游全集校注), (Nanjing: Zhejiang Education Press, 2011).

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