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A Review of Traditional Chinese Timber Architectural Construction Techniques

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Abstract. As one of the world's three major architectural systems, traditional Chinese timber-frame architecture embodies profound cultural value and historical wisdom. This paper aims to provide an in-depth exploration of its historical evolution, the essence of its construction techniques, and its transformation and development in modern times. Based on this, it proposes a comprehensive conservation strategy. The article will first trace the technological development and characteristics of timber-frame architecture from primitive society to the Ming and Qing dynasties, with a focus on analyzing its structural systems, mortise-and-tenon joinery, the evolution of dougong (bracket sets), the modular system, and its outstanding seismic performance. Secondly,it will examine the decline of traditional timber structures and the influence of Western architectural theory during the modern period (1840-1949), as well as the revival, technological innovation, and application of hybrid structures in modern timber construction since the founding of the People's Republic of China (1949-present). Finally, integrating the holistic conservation philosophy of tangible and intangible, static and living heritage, the article will discuss the current challenges in conservation, providing theoretical support and practical guidance for the sustainable development of traditional Chinese timber architectural construction techniques.

Keywords: Timber Structure, Construction Techniques, Technological Change, Intangible Cultural Heritage

1. Introduction

With its long history, unique system features, extensive application, and rich heritage, the traditional Chinese architectural system occupies a pivotal position in global architectural history and is one of the precious legacies of world civilization. For thousands of years, Chinese architecture has always adhered to the tradition of wood structure as the main body and wood craftsmanship as the core. This architectural construction technology system uses wood as the main building material, mortise and tenon joints as the main method of connecting wooden components, and modular design and processing methods, profoundly reflects the Chinese philosophical concepts of the "unity of construction and creation, the unity of Dao and instrument, and the unity of craft and artistry" [1].

With the passage of time and changes in the external environment, these precious timber structures face multiple challenges. For instance, biological erosion (e.g., fungi, insects) and atmospheric effects (e.g., ultraviolet radiation, wind, rain) can damage the wood. In modern times,

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influenced by Western architectural trends and a scarcity of timber, traditional timber structures experienced a period of decline [2].

Given the cultural value they carry, their exquisite craftsmanship, and their performance features such as seismic resistance, the study and conservation of these construction techniques are of critical importance [3]. In 2009, the "Chinese traditional architectural craftsmanship for timber-framed structures" was inscribed on the UNESCO Representative List of the Intangible Cultural Heritage of Humanity, which raised its international profile and prompted the public to re-examine the related heritage and culture [1]. This study will systematically review its construction technology and evolution, focusing on the core characteristics of structural forms, component connections, modular systems, and seismic performance across different periods, thereby providing a theoretical and technical reference for future conservation, restoration, and inheritance.

2. Construction technology and characteristics of timber-frame architecture

2.1. Ancient period (7000 BCE - 1840 CE)

The origins of ancient Chinese timber-frame architecture can be traced back to primitive society. Early humans developed two primary forms of dwelling based on their geographical environment and available materials: "cave-dwelling" (xueju) and "nest-dwelling" (chaoju) [3-5]. In the Yellow River basin, buildings with wooden skeletons and mud walls, evolved from cave-dwellings, were predominant. In contrast, the Yangtze River basin saw the development of stilt-style architecture (ganlan), which evolved from nest-dwellings [4,5].

2.1.1. Two fundamental construction philosophies and structural types

The construction philosophy of ancient Chinese architecture can be broadly categorized into two distinct tendencies: stacking (cengdie) and post-and-lintel framing (lianjia) [6]. The stacking type refers to the layered stacking of load-bearing structures, where the composition is an accumulation of layers. The post-and-lintel type refers to the framed connection of load-bearing structures, where the composition is a juxtaposition of frames.

These two philosophies represent the most primitive and fundamental construction logics of humanity, each having a relatively independent developmental sequence while also influencing and integrating with each other during their evolution [6]. Based on these two construction philosophies, ancient Chinese timber architecture developed three primary structural types: log-cabin style (jinggan-shi), column-and-tie style (chuandou-shi), and pillar-and-beam style (tailiang-shi) [3,6].

1. Log-Cabin Style (Jinggan-shi): This is an ancient structural form characterized by the horizontal stacking of logs or semi-circular timbers, with corners interlocked to form walls and roofs [3,6]. The log-cabin structure does not require the concept of columns, forming walls solely through the stacking of squared timbers. This structure is common in regions rich in timber resources, such as the mountainous areas of Northeast China, Sichuan, and Yunnan. Its advantages include regulating indoor temperature, possessing a certain degree of seismic resistance, and requiring relatively simple materials and techniques [3]. However, it consumes a large amount of timber, and the placement and size of doors and windows are restricted. In terms of construction philosophy, the block-stacking log-cabin structure is fundamentally consistent with the later stacked-layer palace and pavilion structures.

2. Column-and-Tie Style (Chuandou-shi): Originating from the nest-dwellings of the south, the column-and-tie structure is characterized by columns directly supporting the purlins. The columns

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are connected by tie beams (chuanfang) that pass through them, forming a stable frame [7]. This structure lacks the concept of a main beam; instead, the tie beams connect the columns to form the frame. The column-and-tie style typically uses smaller-section timber, which is easier to source, and the overall frame possesses strong integrity and stability.

3. Pillar-and-Beam Style (Tailiang-shi): The pillar-and-beam style is one of the most prominent forms in ancient Chinese timber architecture, especially in large-scale palace and temple buildings [3]. Its basic construction involves placing large beams on top of columns. Shorter columns (guazhu or tongzhu) are then placed on these beams to support shorter beams above them. This process is repeated, with beams becoming progressively shorter at each level, creating a stepped beam frame [3]. Purlins are placed at both ends of each layer of beams, forming the basic shape of a pitched roof. The pillar-and-beam structure provides spacious interiors with fewer columns, making it highly adaptable for various functions.

Ancient Chinese wooden structures are rich and diverse in design. Table 1 is a summary of some of the main types and features of traditional Chinese wooden structures.

Table 1. Comparison of main types and characteristics of traditional Chinese timber structures

Structural Form	Key Features	Main Materials	Applicable Buildings	Pros&Cons	Representative Examples
Cave/Nest Dwelling	Adapted to natural environment; simple, early shelters.	Earth, wood, branches, mud	Yellow River Basin (Cave), Yangtze River Basin (Nest)	Primitive, simple	Hemudu Site, Banpo Site
High-Platform & Early Beam-Frame	Larger scale, strict hierarchy	Wood, rammed earth, tiles	Palaces, ancestral temples	Structural system begins to formalize	-
Pillar-and-Beam (Tailiang-shi)	Beam frames stacked in layers; few columns, large space.	Large-diameter timber	Northern large-scale buildings (palaces, temples)	Spacious but high material consumption and cost	Guanyin Pavilion of Dule Temple, East Main Hall of Foguang Temple
Column-and-Tie (Chuandou-shi)	Purlins directly supported by columns; columns connected by tie beams.	Small-diameter timber	Southern residential buildings	Saves timber but has many columns, limiting space flexibility	"Chuandou-shi" dwellings of the Yi people in Meigu, Sichuan
Log-Cabin (Jinggan-shi)	Logs stacked to form walls and roof.	Timber	Timber-rich regions (Northeast, Southwest mountains)	Good insulation and seismic resistance, but high material consumption; limited door/window placement	Bronze house model from Shizhaishan, Yunnan; "Bengwa" houses in Jomda, Tibet
Stilt-Style (Ganlan-shi)	Elevated on stilts for moisture and flood protection.	Timber	Humid regions (Southern waterside towns, mountains)	Moisture-proof, ventilated	-

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2.1.2. Formation and maturation of the structural system

The Chinese timber-frame architectural system was largely established by the Han dynasty, with the two basic structural forms, pillar-and-beam and column-and-tie, already in existence. During the Tang and Song dynasties, the timber-frame system reached maturity. The planning, design, and construction of buildings, as well as their forms and styles, exhibited a high degree of standardization and formalization [1].

1. Mortise-and-Tenon Joinery (Sunmao): The mortise-and-tenon joint is the most fundamental connection method in Chinese timber architecture. It joins components by fitting a projecting part (the tenon) into a recessed part (the mortise) [8]. This type of joinery possesses excellent flexibility, allowing it to accommodate the minor deformations in wood caused by changes in humidity.

2. Dougong (Bracket Sets,as shown in Figure 2): Dougong are unique components in Chinese timber architecture, consisting of dou (block-shaped wooden pieces) and gong (bow-shaped short timbers). They are stacked layer upon layer, cantilevering out from the tops of columns or beams to support the eaves and the weight of the roof [3,9]. The evolution of dougong is a key indicator of the development of traditional Chinese timber-frame architecture and an important basis for dating ancient buildings [8]. The construction of dougong is intricate, connected by mortise-and-tenon joints, with the pin in the slanted ang (cantilever arm) passing through the lower gong to secure it [3].

3. Modular System: The Song dynasty treatise Yingzao Fashi (State Building Standards) established an architectural system based on the"cai"as the basic module [4]. The cai refers to the cross-sectional dimensions of the gong and fang (beams/rafters), divided into eight grades. The lengths and cross-sectional dimensions of all major components, such as beams, columns, trusses, and purlins, could be determined based on the"cai" [10].

4. Seismic Performance: Ancient Chinese timber buildings possess remarkable seismic resistance [4,11]. This is attributed not only to the mortise-and-tenon joints, which allow the entire structure to "move with the ground," but also to its scientific structural system. For example, the Guanyin Pavilion of Dule Temple in Jixian, Tianjin (built at the end of the 10th century CE),as shown in Figure 1. employs a multi-story frame with diagonal bracing between columns. By stacking three layers of frames and forming rigid ring beams, the overall stiffness of the structure was significantly enhanced [3].

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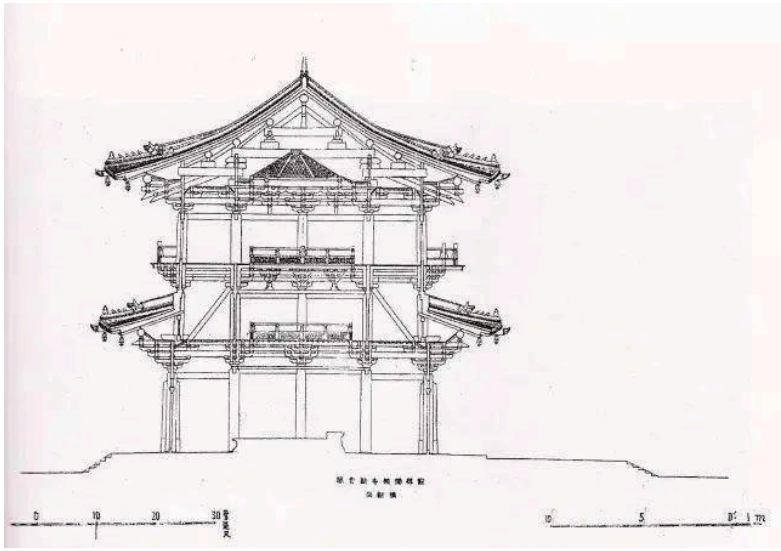

Figure 1. Gate of Guanyin Pavilion at Dule Temple in Jixian county

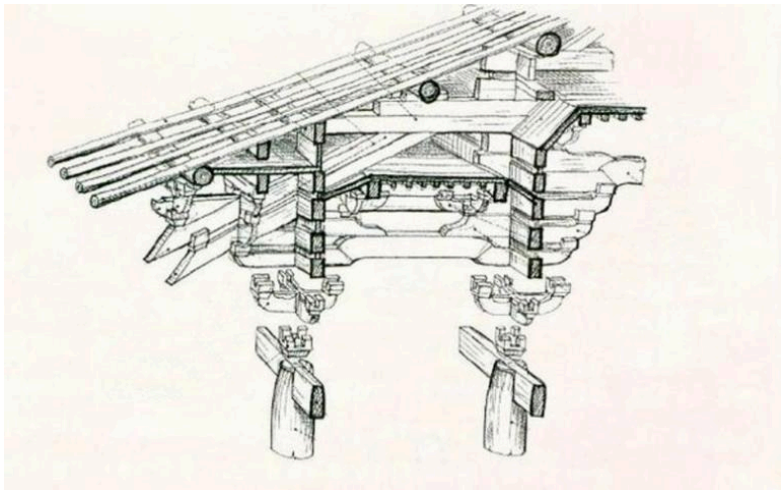

Figure 2. Dougong

2.2. Modern period (1840-1949)

After the Opium War in 1840, Chinese society underwent significant changes and began to passively accept the influence of Western architectural culture. During this period, both architectural typologies and technologies changed remarkably [12].

2.2.1. "Sino-Western eclecticism"

During the Self-Strengthening Movement (starting in the 1860s), the reformist faction advocated for learning advanced Western industrial technology and theoretical ideas. With the rise of industrial architecture, traditional timber structures, unable to meet the demands for large spans and new functions and being wasteful of materials, were gradually replaced by new materials and technologies [12].

At this time, eclectic architecture featuring "Sino-Western complementarity" or "Sino-Western harmony" became mainstream. An example is the office building of the Chengdu Pharmaceutical

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Factory, built in 1906(as shown in Figure 3), which is a brick-and-timber hybrid structure integrating both Chinese and Western architectural elements [12].

2.2.2. Transformation of architectural forms and materials

In the late 1920s, Chinese architecture began to develop vertically, leading to a construction boom of "palace-style" buildings,Figure 4 is a type of "palatial" architecture.. However, the primary structures of these buildings were no longer traditional timber frames but rather reinforced concrete and brick-hybrid structures [12]. A few works began to engage with modernist trends, adopting asymmetrical layouts, corner windows, and other modern architectural languages. During this period, due to changing social needs, technological advancements, and a decline in timber reserves, traditional timber architecture began to wane.



Figure 3. Structure of Chengdu Baiyao factory office building



Figure 4. Meiling Palace (imitation palace-style building)

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2.3. After the founding of the PRC (1949-present)

Since the founding of the People's Republic of China, the development of timber architecture has followed a winding path, from a brief revival to another decline, and then to innovation and development in recent years [12].

2.3.1. Early development and limitations (1949 - 2000)

1. Brief Development of Modernism: In the early years of the PRC, construction activities were mainly focused on repairing war damage and building urgently needed facilities. Influenced by Western modernist architecture and urban planning theories, China built numerous low-investment workers" new villages." These residential buildings were mostly two-story, row-house style brick-and-timber structures, distinct from traditional timber architecture [12].

2. Popularity of Economical and Practical Brick-and-Timber Structures: Due to economic constraints, from 1955 onwards, Chinese architecture began to emphasize economy and practicality, and revivalist styles were no longer mainstream. A common structure used brick or stone for the external load-bearing walls and internal timber columns for support, with timber-frame floors and double-pitched timber roof trusses. This structure was rational, technically simple, and widely adopted [12].

3. Decline of Timber Structures: In the 1980s, due to unchecked construction and rampant deforestation, China's forest resources were nearly depleted. Consequently, brick-and-timber structures were gradually replaced by concrete frame and reinforced concrete structures, and the development of timber architecture was severely restricted.

2.3.2. Innovation and development of modern timber structures (2000 - present)

Entering the 21st century, with the rapid development of China's economy and the pursuit of sustainability, industrialization, green energy conservation in the construction industry, modern wood structures have once again attracted widespread attention in China's construction industry and developed rapidly [11].

1. Technological Innovation in Modern Timber Structures: Natural timber has inherent defects, whereas engineered wood products (EWP) have overcome the weaknesses of traditional timber structures and offer numerous superior properties [12].

2. Main Structural Forms of Modern Timber Structures:Wooden beam structure: including traditional wooden beam-column structure, as well as deformation forms such as cable-stayed beams and tree-shaped columns [12]. Cable-stayed beams reduce the bending moment of beams, allowing wooden beams with small cross-sections to achieve a larger span, saving wood and reducing the impact on indoor space. In addition to supporting the structure, tree-shaped columns can also expand parts of the building or eaves outward, increasing the artistic effect [11].

3. Mixed use of wood and other materials:Combining the advantages of steel and wood, they are light in weight, strong in earthquake resistance, and can achieve prefabricated green construction. Wood-Concrete Hybrid Structures: They make up for the shortcomings of both wood and concrete, and are lightweight, highly seismic-resistant, and economical and practical.

4. Scientific research and engineering applications: In the past two decades, China has gradually resumed and promoted research and applications in the field of modern wood structures. Research covers connectors (nail connections, toothed plate connections, bolt connections, self-tapping screw reinforcement, prestressed sleeve bolt connections), lightweight wood shear walls, wood trusses,

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wood-concrete hybrid structures, steel-wood hybrid structures, and CLT [11]. In terms of engineering applications, lightweight wood structures are widely used in villas, tourist resorts, kindergartens, nursing homes, etc., while glued wood structures are used in large-span buildings such as gymnasiums, exhibition halls, theaters, and bridges.

3. Craftsmanship and the inheritance by artisans

Traditional Chinese timber construction techniques have been passed down through generations via an apprenticeship model of "oral instruction and personal demonstration" The construction industry had a detailed division of labor.

As early as the Tang and Song dynasties, there were specialized crafts for stone, major carpentry, minor carpentry, painting, brickwork, tiling, kiln work, plastering, carving, sawing, and bamboo work. By the Ming and Qing dynasties, the division of labor became even more refined, including major carpentry, finishing carpentry, stonework, tiling, earthwork, scaffolding, bronze and ironwork, oiling and lacquering, painting, and paperhanging [1]. Among these, the head of carpentry (dà mùjiàng or zhǔ mò shīfù) would negotiate the building's grade, form, and style with the client during the early stages of construction and was responsible for controlling the overall dimensions.

4. Conclusion and outlook

The construction techniques of traditional Chinese timber architecture are a crystallization of national wisdom, distinguished in world architectural history by their unique structural systems, exquisite mortise-and-tenon craftsmanship, rigorous modular system, and outstanding seismic performance. The technology has undergone a long evolution: from the primitive concepts of stacking and framing, to the mature standardization of the pillar-and-beam and column-and-tie systems in ancient times, to the transformation and decline under Western influence in the modern era, and finally to the revival of modern timber structures in the new century, driven by concepts of green building and industrialization.

Although traditional timber structures once declined, against the backdrop of global attention to sustainable development, modern timber architecture is experiencing a resurgence due to its advantages of being environmentally friendly, lightweight, seismic-resistant, and suitable for prefabrication. The development of engineered wood products, new connection technologies, and hybrid structures has expanded its range of applications, enabling it to meet the demands of modern buildings, including high-rise and long-span structures.

Currently, the conservation and inheritance of traditional techniques still face challenges. Future efforts must include in-depth research and documentation of traditional skills, using modern technology for digital recording and simulation; combining the apprenticeship model with modern education to train artisans; prioritizing the use of traditional materials and processes in the restoration of historic buildings to maintain their authenticity while exploring new ways to showcase this intangible heritage; and promoting the integration of traditional wisdom into modern timber structure design to achieve a fusion of technology and art, allowing the culture of timber architecture to contribute Chinese wisdom to sustainable development.

References

[1] Liu T. (2012) The Comprehensive Protection of Traditional Chinese Architectural Construction Techniques. China Cultural Relics Science Research, 4, 54-58.

DOI: 10.54254/2755-2721/2025.GL28742

[2] Kara, MA, & Demirci, Ö. S. (2023) An Overview of Historical Traditional Wooden Structure Conservation Techniques. GU J Sci, Part B, 11(4), 707-727.
[3] Guo D, An P. (2020) The Technology of Chinese Wooden Structure Architecture//Thirty Great Inventions of China: From Millet Agriculture to Artemisinin. Singapore: Springer Nature Singapore, 485-515.
[4] Que ZL, Li ZR, Zhang XL, Yuan ZY, Pan B. (2017) Traditional wooden buildings in China//Wood in Civil Engineering. IntechOpen.
[5] Kim Y J. (2011) Architectural representation of the Pure Land: Constructing the cosmopolitan temple complex from Nagarjunakonda to Bulguksa. University of Pennsylvania.
[6] Zhang TQ. (2007) On the Types and Evolution of Ancient Architectural Structures from the Perspective of Constructive Thinking. Architect, (02): 168-171.
[7] D.P. Fang, S Iwasaki , M.H. Yu, Q.P. Shen, Y. Miyamoto, H. Hikosaka. (2001) Ancient Chinese timber architecture. I: Experimental study. Journal of structural engineering, 127(11): 1348-1357.
[8] Wu GF, Sun JC, Huang CJ, Ren HQ, Zhao RJ, (2020) Research progress on mechanical properties of tenon-mortise joints in traditional Chinese wood structures. 20203321136, Chinese, Journal article, China, doi: 10.13360/j.issn.2096-1359.201908030, 2096-1359, 5, (4), Nanjing, Journal of Forestry Engineering, (29–37), Journal of Forestry Engineering.
[9] Ivashko, Y., Chang, P., Dmytrenko, A., Kozłowski, T., & Mykhailovskyi, D. (2021) Influence of Structural Schemes on the Shaping of Historical Wooden Buildings: On the Examples of Traditional Chinese Pavilions, Pavilions of the Chinoiserie Style and Ukrainian Wooden Churches. Wiadomości Konserwatorskie - Journal of Heritage Conservation, 67, 49-60.
[10] Wang JS, Wang ZZ, Tang SQ, Huang YS, YUE ZG. (2016) Analysis of seismic performance and stiffness of ancient architectural pavilions. China Science and Technology Information, (24): 58-59.
[11] Sandberg D, Kutnar A, Karlsson O, Joncs D. (2021) Wood modification technologies: principles, sustainability, and the need for innovation. CRC Press.
[12] Lan Q, Zhang HY. (2020) The Development and Prospects of Modern Chinese Timber Structures. Intelligent Building and Smart City, (01): 44-47.