Linguistic and Philosophical Investigations
ISSN: 1841-2394, e-ISSN: 2471-0881
Vol 23 (1), 2024
pp. 64–102

Harmony of Form and Function: Analyzing the Structural, Aesthetic, and Spatial Layout of Nanjing's Traditional Earth Buildings

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Abstract

Vernacular housing does not just reflect a local culture; the aesthetic that it carries is not only analogical but local. The study aimed to look into the traditional Chinese vernacular dwelling (TCVD) architectural features represented by earth buildings (Tulou) in Nanjing and the spatial layout of conventional Chinese vernacular dwellings represented by earth buildings (Tulou) in Nanjing. Among the traditional TCVD, qualitative research tools focused on architectural features and spatial patterns in detailed earth architectural features and the space structure of the Nanjing earth buildings. Then, the extracted local architectural characteristics and spatial layout characteristics were transformed into visual art, partly linking traditional Chinese character art. The article's theoretical framework consists of building typology, spatial sociology, semiotics, and Feng Shui. Then 69 representative mortise-tenon structures, wooden components, and Tulou architectural elements such as roofs and doors, which were representative of the entirety of the image of the earth building, were finally transformed into characters. The color of the earth building comes from the concept of five lines in the Feng Shui theory system: Wood, Fire, Earth, Gold, and Water correspond to Cyan, Red, Yellow, White, and Black, respectively. The other is based on the idea of "geography and five secrets" and combined with the spatial layout of the cluster of Tulou in Tianluokeng, which will be the architectural concepts of architecture and landscape. Creating symbols, creating characters, creating wooden structures occasionally with creation, creating architectural elements, and creating group creation are mined languages of art in paintings.

Keywords: Structural, Aesthetic, Spatial Layout of Nanjing's Traditional Earth Buildings.

Received: 05 May 2024 **Revised:** 10 June 2024 **Accepted:** 24 June 2024

1. Introduction

During the time frame from the 21st century BC to 4th century AD, China was divided and unified several times. Still, different architectural styles may be generalized for different areas. But houses in that time conformed to an ancient Chinese architectural treatise named "Yingzao Fashi", a masterpiece discussing traditional Chinese architecture, compiling and preserving all Chinese building techniques up to the Song Dynasty. That treatise represented the climax of Chinese architecture and also marked the end of the historical development of traditional Chinese housing. A more complex social system, continuous

warfare, and frequent natural disasters towards the end of the Ming Dynasty threw the whole society into a scene of desolation. Many ancient cities were abandoned, and various historic relics were lost. This was severe damage to traditional Chinese dwellings, and what we see today was just an adumbration compared to the time described in "Yingzao Fashi". Upheaval of rural society in the Ming and Qing Dynasties had brought enormous impacts to Chinese ancient country dwellings. This is reflected by the existence of ancient city ruins in some of the rural areas, and today visitors may get an idea of those traditional Chinese country dwellings in the Ming and Qing eras from those historic ruins.

Development of housing and living environment in ancient China has a long history. By the end of the Neolithic Age about 10,000 years ago, people already began to build rudimental pit or cave-like shelters. Then followed a few millennia, a more pleasant housing style was created and formed, still using pit dwelling, represented by the famous Yangshao Culture. After that, different forms of houses were found in different areas of China, due to different living environments and distinct social systems. With the rapid urbanization and social transformation, traditional Chinese dwelling, a significant representation of Chinese vernacular architecture, is confronting the high pressure from the trend of modernization in today's China. Many of their unique features have been forgotten and replaced by 'modern' ones. Driven by the background mentioned above, this research is focused on documenting traditional Chinese vernacular dwellings in the hope of providing reference and inspiration for those who are interested in heritage preservation, architects testing the relationship between modern buildings and historic settings, and the general public who want to understand more about traditional Chinese houses.

Chinese vernacular dwellings have been intensively studied by art and architectural historians, anthropologists, and archaeologists. In the field of Chinese architectural history, however, a comprehensive study of traditional Chinese dwellings using archaeological approaches has not been realized. Traditional Chinese domestic architecture shares a long and continuous history, which is rich in variety, yet it remains one of the least understood of all the architectural traditions of the world. This book provides an introductory study of traditional Chinese domestic architecture down to the beginning of this century, and will be of value to anyone interested in the evolution of Chinese vernacular architecture. The study of Chinese vernacular architecture not only presents a most direct way to understand the daily life, customs and rituals of the common people in China's history, but also close examination of the basic architecture of any culture provides a means of establishing the fundamental values and technology of that culture. Chinese culture has traditionally stood in curious juxtaposition of the primitive and the sophisticate, and in general, that is reflected in the basic nature of its architecture, even into this century.

1.1 Architectural Features of Traditional Chinese Vernacular Dwellings

The architectural features of traditional Chinese vernacular dwellings are diverse, regionally differentiated, and with various typologies. As a result of the vast territory of China and its diverse topographic conditions, various building forms were created to cater to different needs. Yet there are certain features that are common to the entire building tradition. Here the focus will be on some of the main features giving examples from different types of buildings. Being essentially an agricultural society with a

sedentary way of life, the main type of traditional Chinese dwelling is the walled compound. This is true for all the farming peoples living in North China, all the way from the Mongolian grasslands to the mountainous areas in the West and to the eastern plains. It is also the main dwelling type for the Hakka peoples in the hilly regions of South China. Usually the shape is rectangular with the long side facing south. This is in line with the Chinese way of thinking that the south is the most yang (i.e. sunny) and hence the best direction for living quarters. A typical layout has a three-walled enclosure with the south side left open. This creates a sheltered sunny courtyard which is the centre of activity for the family. The main building is a one or two-storey wooden structure. The style and detailing differs between regions and shows influence from the architectural style of official (i.e. government or landlord) buildings. It is also different between urban and rural areas. The richer farmers and those living close to towns will have dwellings with more 'official' style building. In some regions there are still traces of ancestral halls being the main building and the division into east and west or main and side building that is found in the layout of official buildings. An example of this is the Yang house in Shanxi. This same layout may be applied to a stone and brick walled compound with tile roofs such as those found in the mountainous regions in SW China. The wealthier farmers and also some tradespeople will build shop houses in a similar style to the main building, this is still common in some regions such as in the Walled village in Ding Xiang. As far as living space is concerned, traditional buildings in China and particularly in the villages, are simple in style and construction. The emphasis of architectural skill and decoration was focused on the main building in the walled compound. This was the place of residence for the head of the family. These houses are now disappearing and examples are becoming rare. Each year many are burnt down and then new ones are not built because Chinese rural life is vanishing. This is particularly true for the regions close to big cities where life and building style is becoming steadily more modernized. In provinces like Anhui where the main building had a distinct and well-developed architectural style, numerous dismantlement and reconstruction projects are being carried out by Chinese and foreign architectural historians and restorers in an attempt to preserve examples of ancient buildings. The most well-known of these projects is in Xidi and Hongcun.

1.2 Earth Buildings (Tulou)

The earth building, known as tu lou (Mandarin), is commonly found in Yongding County and in Nanjing County, Fujian Province, China. It is an enclosed, fortified, and clustered housing complex, usually rectangular or circular in configuration around a central shrine. As the name implies, the earth building is constructed with earth, mixed with stone and bamboo, and is found mostly in hilly areas. The earth building has been described as a large baguo house. It shares some features of the baguo house. A very wide outer ring is used to encircle the buildings within. This is a gallery-like space for walking, with the housing units forming the inner, high-walled ring. The buildings are usually two, three, or four stories in height, with an average of 15 rooms on each level. In most cases, there is only one entranceway, and the gate is built of wood and is sturdy and heavy, so that it can be closed and secured from within. This makes the entire structure a self-contained fortress, and there are no windows at ground level on the outer ring. Stairways are often built into the thick earthen walls, giving access to the upper levels. The tulou has remained a durable building, one of the few types to have come out of pre-modern China, and still be in wide use today.

When properly maintained and renovated, it can last for centuries. Today, the earthen architecture is slowly disappearing as a result of the ban on its production, and many remaining earthen residences are in various states of disrepair. Efforts have been made to preserve the remaining tu lou, especially the Hongkeng Cluster in Nanjing County and the entire area of Yongding, which represents the largest and best-preserved group of earthen buildings. Tulou has also been subject to violent, large-scale, illegal demolitions in incidents such as the case in Jiangyou Province, Sichuan, 2004 and in Yongding, Fujian, which led to the destruction of an all-important earthen drum tower at Gaobei Tulou cluster, as well as many other earthen structures. In 2008, the Chinese government released a statement to call for stronger measures to protect the tus, with concrete plans to prevent further large-scale demolition. Such measures, including a massive relocation project, are still in progress today to protect earthen structures as an important part of Chinese architectural heritage.

1.3 Structural Design

The drum-shaped wall of Tulou is from the method of bagging wall built by Han people. The method is to erect small wooden strips level by level and in turn and inlay them into mud, and mix lime or ash with sand, glutinous rice, tung oil as well as water to build into mud. After the mud is compacted, it will do to inlay the walls with wooden and bamboo chips. The wall made in this way is so solid that the chips made in the wall even will make it impossible to go through with a spear. As an earth building, it's with higher stories and more families and increase the wall thickness of the first floor with adding subsequent stories. Some of the earthen buildings improve the compressive capability of the walls by making them in steps. In a word, the thick walls and the selected materials build a good condition for the earth buildings of Hakka. The wooden structures of earthen buildings are susceptible to humidity and erosion, consequently the components of the earth buildings comprise stone materials, wood and iron materials for connecting the parts together, which make up a mixed structure of stone and wood. The stone materials include flagstone, cobble and other actual stone materials. Steps are also taken to hike the compressive strength for the wall base. This mixed structure of stone and wood has increased the overall strength of the earth buildings.

The objective of this study is to determine the architectural features of traditional Chinese vernacular dwellings represented by earth buildings (Tulou) in Nanjing and to assess the spatial layout of traditional Chinese vernacular dwellings represented by earth buildings (Tulou) in Nanjing. Furthermore, to create artworks based on architectural Features and Spatial layout of Nanjing earth buildings.

2. Material and Methodology

This article employs qualitative research tools to analyze the architectural features and spatial patterns of Nanjing earth buildings, a subset of traditional Chinese vernacular architecture. The research transforms these features into visual art linked with traditional Chinese characters, especially oracle bone and bronze inscriptions. The study notably focuses on the Tianluokeng Tulou Group, extracting and artistically interpreting various architectural elements like mortise and tenon structures and Tulou's characteristic colors derived from Feng Shui's five elements theory. The methodology integrates anthropology, architecture, art history, and cultural studies, and is divided into field observation, archival

research, and artistic interpretation. Field visits offer direct insights into the architectural and cultural nuances of Nanjing's Tulou, while archival research provides historical context. Artistic interpretation then translates these insights into visual forms, integrating traditional art styles and Feng Shui principles.

The research also discusses the materials used in Chinese vernacular dwellings, noting regional differences influenced by climate and resource availability. Traditional materials ranged from stone and brick in the north to timber in the south, each selected for durability and suitability to local conditions. The study touches on historical shifts in materials and techniques, reflecting broader changes in Chinese architecture.

2.1 Use of Qualitative Research Tools

The research utilized several qualitative research tools to systematically collect and analyze data on the architectural features and spatial layout of Nanjing's traditional earth buildings (Tulou). These tools included in-depth interviews, participant observations, archival research, and case studies.

In-depth Interviews: Conducted with local residents, architects, and cultural historians, these interviews aimed to gather personal insights and historical knowledge about the Tulou. A semi-structured interview format allowed for both guided questions and open-ended responses, facilitating rich, qualitative data collection.

Participant Observations: Researchers spent extended periods within Tulou communities, observing daily life and the use of space. This immersion enabled the researchers to gather firsthand data on how the architectural features of the Tulou influence social interactions and community activities.

Archival Research: Historical documents, building plans, and previous studies on Tulou architecture were reviewed to contextualize the current research within the broader historical and cultural framework. This archival work helped identify the evolution of architectural styles and construction techniques.

Case Studies: Detailed case studies of specific Tulou buildings, such as the Tianluokeng Tulou Group, provided a focused analysis of their unique architectural features and spatial layouts. These case studies combined observations

2.2 Decorative Elements

At Peitian, there are also early Qing dynasty residential buildings belonging to a lineage named "yang". They are typically deep and narrow two-story buildings with 3-5 rooms on each level. Between every two rooms, there is a common vertical stone slab. At yangcuo building in donglou, there is a set of 6 carvings that depict folk stories and ballads. The story content correlates with the verse written under the competition above. Most of the carvings depict human activities. Narrative carvings are most commonly seen on brick buildings, where horizontal stone slabs were installed between every two stories. An example would be the carvings on the walls of the large earth buildings at Peitian. This board has been included in the list of protective cultural relics. The carvings depict the stories behind the survival of the ancient Hakkas, such as "thatched living in huts, hoeing weeds, making of thatching grass, toiling to the shade of paddy field dam".

Dumpling wood buildings' all aware lie, cloud rain head accompany built one, the chuanchuan board my makeshift here, outside this sow fields content level. The chi nuo board verse says. Carvings are considered the most important and typical decorative elements of traditional Chinese vernacular dwellings. They are usually seen on brackets, beams, lintels, uprights, doors, and window frames. Tile carvings and stone carvings are secondary. The topics of the carvings could be largely categorized into four groups: auspicious motifs (mainly figurative), historical stories, current events, and modern motifs (mainly flowers and birds). Folk art reached its peak in the carving arts. The carving techniques are very exquisite, especially on brackets, the carving strokes could be as thin as 2-3 mm. Due to the fact that most of the vernacular buildings were constructed between the Ming and early Republic of China period, the wood often used in the carvings was either nan or huang wood (nimbus or Phoebe nanmu and Phoebe zhennan).

2.3 Spatial Layout of Traditional Chinese Vernacular Dwellings

Because of the broad range of different types of dwellings and regional variations on culture and climate, it is impossible to make generalizations on the type of organizational structure in traditional Chinese dwellings. However, there are some key features that can be identified regarding the organization of spaces. In traditional Chinese society, each and every member of a family was required to perform his or her duties in accordance with the traditional social norms. Privacy was not a requirement and often it was customary for 2 or even 3 generations of one family to inhabit the same house. Duties such as cooking, drawing water, poultry and livestock raising, and even some types of cottage industry, required specific rooms or spaces for them to be performed. It is because of all these factors that traditional Chinese homes have a deep and complicated structure of organizational spaces.

Organization of space is an important aspect to be considered in domestic architecture. Designing a living space cannot be done haphazardly without knowing the needs of the user. It is not always an easy task to determine the ways in which space should be organized. People have different living habits and custom, they belong to different cultures and different economic backgrounds.

2.4 Organization of Spaces

The miin kia is typified by a formal axial arrangement of buildings along a north-south axis. This in itself is a diagram of Confucian cosmology which saw the universe as an ordered hierarchy of differentiated opposites with North and east being positions of dark and disorder. At the head of the household's plot there is the chieh t'ang 章堂, the central hall which is larger than the central hall of any other house type and is the symbolic centre of the universe. At right angles to the South end of the central axis there is the kuei t'an 閨檀, a pair of ceremonial washing basins. The space between has a well. These features are particular to the miin kia. The rest of the axis is a series of halls large and small and interspersed with empty space. At the southern end of the axis and usually screened off by a wall is the living area proper.

The most prestigious house type is the miin kia, literally "gate house". This rarely built type represents an ideal dwelling and its universal plan and features are codified in the Ts'ang 族 Ch'i T'u 章氏祇圖 (Family Lineage of the Ts'ang Clan), a genealogical record of the seventeenth century, which gives plans

and designs for the house built of brick and stone. The house is the residence of a land owner/official (shang nung) and its layout according to Ts'ang mirrors the network of dwelling and town on a macrocosmic level.

In traditional Chinese society, the house type reflects the hierarchical social structure it embodies in spatial terms. This is a typical feature of society in South China. The dialectical term "kia" (house and family) which stands for family and social unit, is a key concept in this dialogue between social structure and space in China.

2.5 Courtyard Design

Step outside the front door of a traditional Chinese dwelling, and practically the first thing one does is step over the threshold of a courtyard. The entrance courtyard can be seen as a communal area that was still part of the outside world, and in the most ancient times, it was kept for entertaining guests and carrying out various craft and domestic activities. Ancestors of the modern-day suburbanites who wish to escape the urban environment at weekends, ancient Chinese would have sought to find themselves a quiet spot amidst nature, and it was this desire which gradually transformed the courtyard from a public and open space to a private and secluded one. The courtyard is an essential element of the traditional Chinese vernacular dwelling; it is the soul of the house, a microcosm that represents and creates the family and social order. Functionally, the courtyard serves to provide an illuminated and ventilated interior and provides a space for the performance of domestic chores. This reflects a universal trend in which a high proportion of human activity (up to 90%) was carried out in an outdoor environment, which has only recently been reversed in some countries due to the increasing availability of leisure time and income.

A courtyard is an area enclosed by walls or buildings, open to the sky. It is often smaller than a garden and is used for a variety of purposes, including cooling, a private area, and a place to grow and enjoy plants. In many ways, Chinese courtyards are similar to European ones. During the Spring and Autumn period (770-476 BC), Chinese nobles and scholars began to build large houses with walled gardens in keeping with the Confucian pattern of integrating living with nature, and this is a theme that has recurred throughout Chinese architectural history.

2.6 Living Areas

The number of rooms in traditional Chinese vernacular dwellings varied, but the principle was to provide more rooms with a view across the courtyard. Peasants' dwellings often only had one main living room or a two-bay room (Er Jia) in the north, and one small room Southern Room (Nanfang) often at the back. But the standard size was a three-bay room in the north and a two-bay room in the south. This was considered to be the bare minimum for an average-sized family. A three-by-three bay hall formed the center; it was reserved for senior members of the family and was often used for meals and entertaining guests. The Shan was a small raised platform at the southern side of the hall, which often housed the family shrine. The different levels in the hall and its proximity to the main living room would make it more open-air and a place where family members would relax together. It was an important space for family life, but larger halls were also used to balance the structure of the house around it and may have been used for public meetings of family members from neighboring houses. The surrounding rooms were primarily for

storage and as rooms for children or newlyweds to live separately, with the latter scenario often being in rooms that were extensions to the original plan. In more complex homes, the central hall would be connected to the main living room by a one-bay corridor with additional rooms attached to the corridor. A rich and/or high-status family may have one or more rooms specially built for hosting important guests.

2.7 Communal Spaces

In certain areas of the ancient Orient, the livelihood of the people is based on a highly communal mode of living. Examples of this are seen in the combined family system and the joint-living groups found in certain villages. In these cases, the manner in which people interact within their own exclusive social group, as well as the connections made between separate units and shared spaces, say much about the nature of community within the larger society. Proper clarification of the communal modes of living found in rural China is not the easiest thing, for there is tremendous variety depending on the particular socio-economic grouping of families in question. However, a very specific model of community is seen in the traditional Chinese farmstead with its extended family system. Here, communal living is a strong assertion of the family unit and its membership, with a core value placed on togetherness. The physical representation of this is the shared spaces found within the family unit, and a wide variety of them speak about the nature of familial and communal interaction.

2.8 Connection with Broader Architectural Theories

To situate the findings within the broader academic discourse, the research drew on several architectural theories and urban planning frameworks:

Building Typology: The study examined how the Tulou fit within traditional Chinese building typologies, emphasizing their unique combination of residential and defensive functions.

Spatial Sociology: The social dynamics within the Tulou were analyzed using spatial sociology concepts, highlighting how the architectural layout fosters community cohesion and social interaction.

Semiotics: The symbolic meanings of architectural elements were explored through semiotic analysis, linking the physical features of the Tulou to cultural and historical symbols in Chinese society.

Feng Shui: The principles of Feng Shui were applied to understand how the spatial arrangement and orientation of the Tulou align with traditional Chinese cosmological beliefs. This theoretical framework helped explain the use of specific materials and construction techniques that reflect the harmony between human habitation and natural forces.

2.9 Data Analysis

The data analysis process was systematic and transparent, ensuring that the conclusions drawn were robust and credible:

Coding and Thematic Analysis: Qualitative data from interviews and observations were transcribed and coded using thematic analysis. This involved identifying recurring themes and patterns related to

architectural features and spatial layouts. NVivo software was used to assist with data management and analysis, providing a clear audit trail of the coding process.

Triangulation: Data from multiple sources (interviews, observations, archival documents, and case studies) were triangulated to enhance the reliability of the findings. This approach ensured that the conclusions were supported by diverse and corroborating evidence.

Member Checking: Preliminary findings were shared with interview participants and community members for feedback and validation. This member checking process helped verify the accuracy of the interpretations and incorporated local perspectives into the final analysis.

SPSS version 22.1 has been used for the statistical analysis.

2.10 Reliability and Validity

To further ensure the reliability and validity of the research findings, several strategies were employed:

Detailed Audit Trail: A comprehensive record of all research activities, including data collection methods, analysis procedures, and decision-making processes, was maintained. This audit trail provided transparency and allowed for the replication of the study by other researchers.

Reflexivity: Researchers maintained reflexive journals throughout the study, documenting their reflections on the research process, potential biases, and interactions with participants. This reflexivity helped mitigate researcher bias and enhanced the credibility of the findings.

Peer Review: The research design, methodology, and findings were subjected to peer review by experts in traditional Chinese architecture and qualitative research. This external review process provided critical feedback and ensured the academic rigor of the study.

3. Results and Discussion

3.1 Architectural Characteristics of Nanjing Tulou

According to the interview with Mr. Huang Hanmin, we learned that the architectural features of the Nanjing Tulou are unique and reflected in the materials, appearance, and internal wooden structure. Specifically, from a material perspective, the materials used for Nanjing Tulou are generally sourced locally (except for a few materials related to feng shui or special requirements of the wealthy), which are natural and retain the properties of natural transformation but also have traces of artificial chiseling. For example, the earth walls are rough but have traces of whitewash, and the pebbles need to be processed simply to be stacked stably. The roof tiles and bricks made of clay have a heavy ink color of Chinese blue tiles and are arranged in a relatively orderly manner. Secondly, the geometric beauty of the Tulou's shape, combined with materials and craftsmanship, forms a unique typology system. For example, the form of rammed earth walls combined with circular construction is representative of China's rammed earth system. The use of the cut tile method on the roof also has the characteristics of Nanjing Tulou. These appearance features not only have symbolic meanings but also, as Mr. Huang Hanmin puts it, these simple and elegant Nanjing Tulou are like silent poems, three-dimensional paintings, solid dance poses, and rhythmic melodies that evoke people's imagination. Like “flying saucers falling from the sky, mushrooms growing on the ground” dotted on fields and riverbanks, they are arranged in an exquisite and unique way and are known as “the world's unique mythological mountain village architectural model.” Finally, the internal construction system of Nanjing Tulou still adheres to the most core wooden components system in traditional Chinese architecture, including the combination of through-beam style and raised-beam style, as well as the use of mortise and tenon structure, a universal language with Chinese characteristics in wooden components.

Therefore, studying the architectural features of Nanjing Tulou can not only extract several representative Chinese wooden structure image symbols but also achieve the purpose of analyzing representative Chinese rural dwellings. (Huang, February 2, 2023: Interview)

In this section, we will take one of the Tulou buildings in Nanjing, as the main object of discussion, and discuss the architectural characteristics of the materials, external modeling and internal structure (Figure 1).

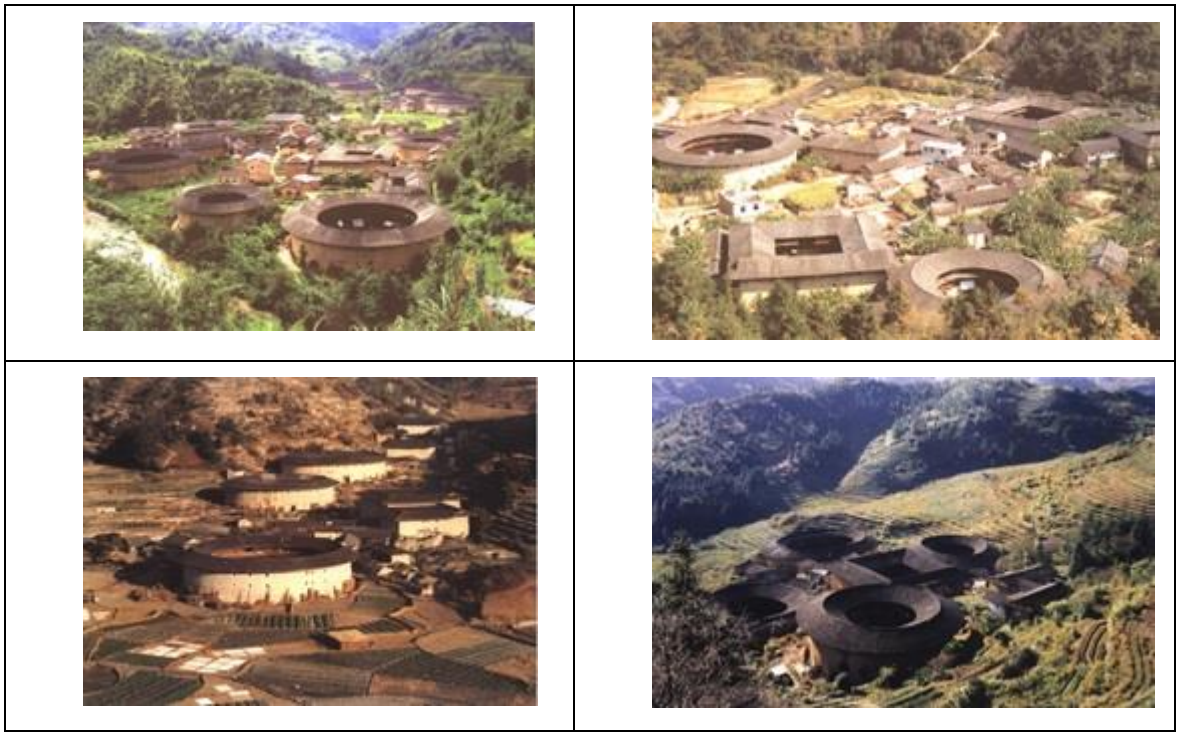


Figure 1: Architectural characteristics of the materials, external modeling and internal structureof Tianluokeng Tulou Group

In an interview with Mr. Huang Hanmin, a well-known earth building research expert, we learned that the materials used by the Hakka people in Nanjing to build traditional Tulou mainly come from the abundant local resources of soil, wood, and sandstone in the mountainous areas. These materials are mainly reflected in the Tulou roof, walls (earthen walls), wooden components, and main entrance. Among them, the materials used for walls, roofs, and wooden components are the main materials. (Huang, February 2, 2023: Interview) (Table 1)

Table 1: Material Used

Material Area	Main Materials	Illustration
Wall	Fine Red Soil; Field Mud; Old Wall Mud; Broken Bricks and Stones	

Roof	Clay	
Wood Component	cedar wood	
Main Gate, Stone Steps, Foundation	Bluestone	
Other Areas	pebbles, white lime, metals.etc	

3.1.1 Wall Materials

Rammed earth walls are mainly divided into ordinary rammed earth walls and adobe walls based on the material composition and ramming process. The former is built by ramming local fine red soil, field mud, old wall mud, and broken bricks and stones mixed with water to a suitable moisture content; the latter is constructed by ramming local fine red soil, lime, and sand in certain proportions. Some Tulou buildings also use glutinous rice, brown sugar, and egg white as additives to enhance the toughness of the walls (Table 2).

Table 2: Wall Material.

	Category	Materials	Alternative Additives	Practice
Wall Materials	Ordinary Rammed Earth Walls	Fine Red Soil; Field Mud; Old Wall Mud; Broken Bricks and Stones	Glutinous Rice; Brown Sugar; Egg White	Mix with water to a suitable moisture content and then rammed.
	Adobe Walls	Fine Red Soil; Lime; Sand		

The local soil in Nanjing is mainly red soil, typically brown-red or yellow in color. Red soil tends to expand and has high stickiness when exposed to water, but it shrinks and cracks easily when dry. Therefore,

in the construction of Nanjing Tulou, a certain amount of field mud (also known as “field bottom mud,” generally uncultivated soil from paddy fields), old wall mud (abandoned rammed earth), river sand, lime, and other materials are used as aggregates. Some Tulou buildings even use glutinous rice, brown sugar, and egg white as adhesives and curing agents. The materials are proportioned reasonably according to the differences in soil quality in various regions.

It is important to note that in the process of mixing these raw materials, there is a significant step known as “ripening.” This is because the collected red soil and other materials cannot be used directly and need to be continuously mixed, watered, turned over, and finely ground. The ripening process usually takes three to five days, and straw is often added at night to prevent moisture evaporation. Sometimes these soil materials are left to mature for several years, requiring continuous turning during this period. Through this process, the soil blends thoroughly. When the prepared rammed earth material is ready, the wall construction process begins by ramming the earth walls (referred to as “xingqiang” by the Hakka people). Wall tamping tools (referred to as “qiangkuai” by the Hakka people) and other complementary tools are used during the construction. Each section of the earth wall is called a “ban,” and bamboo or cedar strips are used between each section for connection, known as “tuogu” by the Hakka people. This not only strengthens the structure but also enhances the overall integrity of the wall surface. In square Tulou buildings, the corners of the outer walls require special reinforcement. Typically, thicker cedar bars or long wooden boards are used to form an “L” shape (referred to as “gougu” locally), buried into the wall. A set of “gougu” is placed every three sections of earth wall to enhance the overall integrity of the wall corners. This reinforcement method is widespread in Tulou construction and is one of the key reasons why Tulou buildings can withstand natural disasters. The corners of the earth walls are sometimes reinforced with cobblestones sourced from rivers. These stones, after processing and placement, not only serve as flood protection but also support the earth walls, enhancing their stability. Additionally, as cobblestones are a natural stone material with high hardness and durability, they are resistant to environmental erosion. Therefore, using cobblestones as materials for the corners of earth walls can effectively improve their flood resistance, seismic performance, and prolong their lifespan.

3.1.2 Roof Materials

The roof of Nanjing Tulou is mainly made of small blue tiles and blue bricks fired from clay, laid on wooden beams. Clay is a natural soil material containing clay minerals, which is inherently plastic but hardens and becomes brittle when dried or fired. In the selection of clay, it can be sourced locally or transported from elsewhere, generally depending on the family's economic conditions. The selected clay is processed, shaped, dried, and fired to produce the small blue tiles needed for the Tulou, with the color after molding not being blue but dark blue or gray-blue, appearing close to black from a distance. These small blue tiles are laid according to the different roof shape requirements, creating the unique appearance of the roof.

In the production of blue bricks, clay is usually mixed with water to make brick blanks, which are then fired in a brick kiln (at temperatures generally ranging from 900°C to 1100°C for 8-15 days) to make bricks. The fired blue bricks are generally dark blue-black, with high density, no deformation, and no color change, usually serving to reinforce the roof when placed on the small blue tiles.

They effectively prevent rainwater from seeping into the interior and help maintain indoor temperature. In addition, these blue tiles have fire-resistant properties due to the clay itself, providing fire protection. The fresh and natural color of the blue tiles gives a simple and fresh feeling, as well as a sense of stability and antiquity.

3.1.3 Wood Component Materials

The wood components of Nanjing Tulou are mostly made of locally common cedar wood. Cedar wood is preferred because it thrives in warm, humid conditions, is shade-tolerant, and suits the climate in Nanjing. Cedar wood is typically yellow-white in color, with excellent quality, moderate hardness, ease of processing, corrosion resistance, and a faint fragrance. These excellent characteristics make cedar wood an

ideal material for the wood components of Nanjing Tulou. In the various wood components of Nanjing Tulou, cedar wood is widely used and crafted into various forms and functions, with processing ranging from simple to intricate. These cedar-based wood materials give Nanjing Tulou a more robust, durable, and rustic character.

3.1.4 Main Gate, Stone Steps, Foundation Materials

In the construction of the main gate, stone steps, and foundation materials of Nanjing Tulou, bluestone plays a major role. Bluestone is a common type of stone in Nanjing, usually sourced from local rivers. Bluestone has a fine texture and is primarily blue or emerald green in color. Despite being light in weight, bluestone is hard, heat-insulating, corrosion-resistant, wear-resistant, and resistant to weathering. It has a smooth, glossy, non-porous surface, making it a natural cultural and decorative stone. Its application in Tulou is not only due to its excellent texture but also because of its stable physical and chemical properties, allowing it to withstand the complex living environment of Tulou. Therefore, the use of bluestone not only adds a natural beauty to Tulou but also demonstrates the meticulous selection of materials and cultural heritage in the construction of Tulou by the Hakka people in Nanjing.

3.1.5 Materials for Other Areas

The materials used in the main areas of Nanjing Tulou are mainly pebbles, white lime, metals, and other materials collected from local rivers or streams. Among them, pebbles have the natural stone characteristics of compression resistance, wear resistance, and corrosion resistance, making them an ideal green building material. The Hakka people in Nanjing utilize these good physical and chemical properties of pebbles to pave courtyards, making the courtyard ground sturdy, neat, and colorful. In addition to paving courtyards, pebbles can also be used in wall corners or foundations (Figure 2).

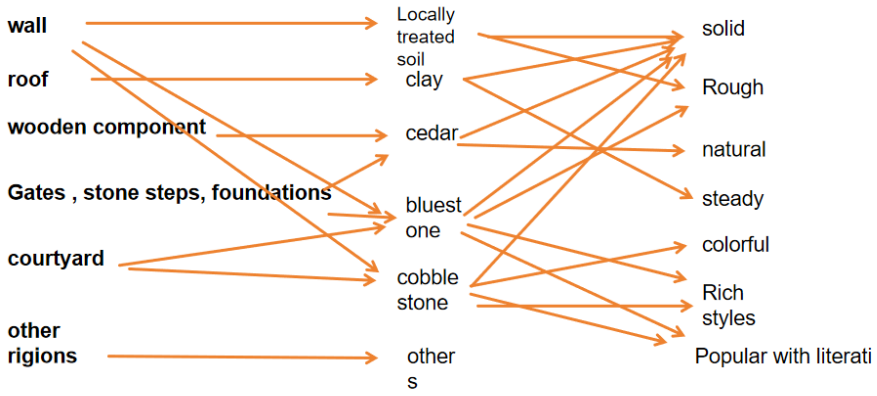


Figure 2: The materials used in the main areas of Nanjing Tulou

In summary, the materials such as soil, wood, sand, and stones used in Nanjing Tulou, although processed to some extent, still adhere to the characteristics of the original materials, providing a safe and comfortable living environment for the Hakka people in Nanjing. These materials have their own natural physical properties and, in the unique cultural background of the Hakka people in Nanjing, convey their unique living traditions and reflect the traditional Chinese cultural connotations of "harmony between man and nature" and "the unity of heaven and humanity." Therefore, Nanjing Tulou is not only a unique residential architectural form but also an important part of traditional Chinese culture.

3.2 External appearance

Swiss psychologist Carl Jung proposed the concept of "archetypes" based on the "Primitive Hut Theory" in "Archetypes and the Collective Unconscious". This allows buildings, no matter how complex, to be ultimately traced back to a few basic geometric shapes. Through the reductionist approach of "prototype", that is, by returning to the original motivation, the most essential elements of architecture are obtained and elevated to the level of law or principle. (Jung, 1969)

Combined with the research on the history of the development of Tulou in Fujian by architectural historians represented by Huang Hanmin, the architectural form of Tulou in Nanjing originated from the early “Walled City” and “Fortress”, and evolved into a roundabout under the specific historical and geographical conditions, combined with the traditional courtyard of the Central Plains, which was a form of residence in the middle of China. Under the specific historical and geographical conditions, the Hakka Tulou evolved into the enclosed form after combining with the traditional courtyard form of the Central Plains. These Hakka earth buildings are generally internal corridor buildings (i.e., one or more corridors connecting multiple independent residential units), and according to the division of external shapes, they contain round, square, oval, arc, fan, horseshoe, five phoenixes, half-moon, zigzag, bagua and other variant forms of earth buildings, but the main round and square buildings represent the widest distribution, and are more typical. From the overall image of the exterior, square earth building and round earth building have common features, namely, the earth yellow thick earth wall dragged on a black and gray wide roof. The dense sense presented by the splicing of small green tiles on the roof and the single form of the earth wall form a contrast between sparseness and density, complexity and simplicity; at the same time, the regular arrangement of the roof due to the special process and the randomness of the wall texture form a contrast between regularity and irregularity. On the whole, Nanjing Tulou is close to nature in the selection of materials, so its architectural form is more original, and due to the huge volume of the roofs and walls, the whole appears to be thicker and heavier. In terms of the internal structural features, the Nanjing Tulou's interior adheres to the main feature of traditional Chinese architectural structure - wooden structure, and its structural form is embodied in the through-bucket structure. In terms of the characteristics of the wooden structure of Nanjing Tulou, the overall response of the workmanship is relatively simple and the structure is relatively simple. In addition, the internal and external architectural elements of the Tulou buildings also reflect certain decorative features, which on the one hand reflect the dominant traditional Chinese cultural concepts (Han cultural concepts), and on the other hand reflect the unique aesthetic interests of the Hakka people (Figure 3).

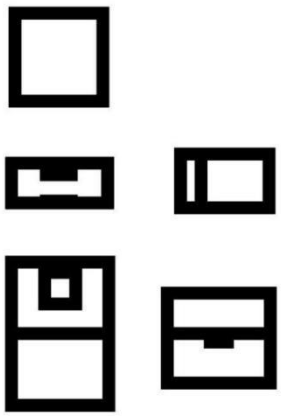
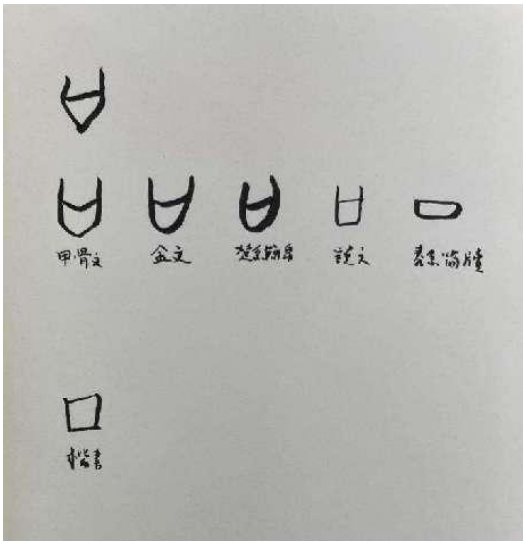
Figure 3: Hekeng Tulou Cluster

3.2.1 External image characteristics

Combined with the early research of Mr. Liu Dunzhen,(Liu, 2004) according to the typical morphological features of the square buildings in Nanjing Tulou, they can be divided into three groups to be analyzed (as shown in the following figure). Among them, the top picture is the first group, which shows the most basic form of the mouth shape (or back shape), this shape is simpler, only retaining the main body of the square outer ring of the house part, and based on this divided into the middle of the patio and the inner courtyard, constituting the earth building of the bulk of the outer solid hollow form characteristics. The middle group is framed by a mouth shape, which is slightly differentiated in the interior and is rectangular in shape. The left picture is divided by a line in the vertical direction, while the right picture is only slightly differentiated at the upper and lower lines. The following two groups take the mouth shape as

the basic feature and combine and remodel it, such as the left Wo Gui Lou is divided into two parts of the mouth shape, and the upper part of the mouth shape presents the feature of a mouth in the mouth because of the construction of the ancestral hall. The Zhende Building on the right is also divided into upper and lower groups, but only slightly changed in the division. Overall, these three groups of buildings are based on the changes and combinations of the mouth shape, and all show the properties of the character, such as the first group of the mouth shape, the second group of the left side of the mouth is still the mouth shape, but the form is flattened, and the right side of the form of the "day", the third group of the left side of the upper for the "day", the right side is the day, and the third group of the left side of the "day". Overall for the day, the right is the day. This type of housing style is called "Alcove" by the local people. In addition, from the point of view of Pierce's semiotics, this kind of mouth-shaped architectural form not only fits the morphological characteristics of "mouth" in shape, but also corresponds to the Chinese meaning of "mouth" in its own function (from the point of view of meaning, "mouth" in Chinese itself is "口"). In Chinese, "口" itself means mouth. The fact that the mouth can store food as well as refer to entry and exit is itself a basic function of architecture) (Table 3).

Table 3: Plan sketches of square earth buildings with "mouths".

The round earth building is the change of the shape of the square earth building, including the square circle and the irregular circle which is changed on the basis of the square circle. According to the conclusion of scholar Huang Hanmin's research: for the Hakka people, the earth building is the square building first, and then the round building. And the round building is for the development of the square building. This kind of earth building firstly cuts off the corners of the square earth building and becomes smooth treatment. The shape of the round building also has the characteristics of the mouth character, but it is more abstract in the senses. Combined with Liu Dunzhen's summarization of the shapes of earth building plans, Nanjing earth buildings can also be divided into three groups (as shown below) Among them, the uppermost group is basically circular, characterized by the different proportions of the outer ring formed by the earth walls and roofs in the overall area. The outer ring is larger on the left and smaller on the right. The two figures in the center group are both combinations of circular mouths whose forms also reflect the proportions of the rings, but present a double proportion of inner and outer rings. The center of the left of these images is characterized by a circle combined with a fan. The bottom group is the most complex, with an outer ring that maintains the circular mouth shape, but the interior is a scattering of arcs that, together with the outer ring lines, form the overall architectural form and share the center of the circle, reflecting both the whole and the identity.

Take the Tianluokeng Tulou as an example. Its Tulou are the simplest circular or square ones (there is an ancestral hall inside each, but the area is small, so we will not refer to it here). Among them, Zhenchang Building, Ruiyun Building and Hechang Building are square or close to square, while Wenchanglou is oval and Buyun Building is a square building (Figure 4).

Figure 4: Overhead view of Tianluokeng Tulou

From the external facade of Nanjing Tulou's architectural shape, although the complexity of the Tulou style shape, looking at the external shape presented by a single building, it can still be summarized as a shape mainly composed of roofs and earthen walls. Taking the five earth buildings in Tianluokeng Earth Building as an example, the overall roof above is trapezoidal, with the left and right sides of the trapezoid sloping outward. This is mainly due to the construction method of the two-sided slope of traditional Chinese architectural roofs. The outer perimeter line of the earthen walls slopes inward from bottom to top, based on the architectural feature of the Tulou being divided from bottom to top. In addition, the roof decorated with tiles also reflects distinctive features: first, the blue tile roof and the wall part have eaves of more than 2 meters; second, the ridge and eaves lines are prominent and strong; third, the roof presents a dense feature due to the combination of tiles. In addition, the four circular buildings in Tianluokeng Earth Building are arched, while the central square building is square. The lower side of the door is the base of the earth building, which appears rectangular from the facade and is built with pebbles or bluestones (Figure 5).

Figure 5: Front view of Tianluokeng Tulou

As a whole, the exterior of Nanjing Tulou is mainly composed of the wall part and the roof part. The wall part includes stone wall corners, earthen walls, bluestone or wooden doors, window openings, etc., while the roof is made up of small blue tiles and blue bricks. The blue bricks become pressure tiles because

they are pressed on the small blue tiles. The windows on the walls are generally arranged horizontally or in an approximate horizontal arrangement, as shown in the figure below. In terms of their distribution, they are irregular but have a certain regularity. These windows are organized into relatively uniform arrangements in single or multiple groups, but the distances between groups vary in size; the windows are generally distributed on the second and third floors. Since the area of the window openings is relatively small compared to the wall area, but the external concrete color with paint is relatively prominent, it overall decorates the black-gray roofs and the yellow-red earth buildings.

3.2.2 Tianluokeng Tulou

The roof of Nanjing Tulou is actually divided into the external visible tile roof and the internal wooden structure (to be analyzed later, not to be repeated here). The tiles are arranged in the traditional Chinese tile roofing style, i.e., the tile roofing (as shown in the picture below). The tile roof is also known as "yin-yang tile" or "butterfly tile". Its main feature is that the tiles laid above and below the roof surface are slate tiles, and two sets of slate tiles are arranged in alternating longitudinal stacks, with one pitching and the other tilting, and with one yang and one yin, constituting a ridge of hing tiles (Figure 6).

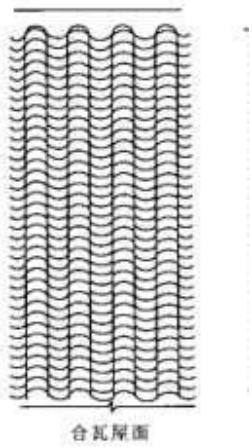


Figure 6: Sketch of a hinged tile roof

Such as Tianluokeng Tulou roof surface, the upper position of the plate tile each group has about 4 layers of superposition, regularity along the longitudinal arrangement and the gap between the tile ridge is about 1/2 of the width of the plate tile. this not only constitutes the regularity of the arrangement, but also strengthens the visual sense of concavity and convexity and contrast. Round earth buildings also utilize the practice commonly known as "shear tile". This is a kind of tiles used to deal with the requirements of the round roof surface curved changes in the way of laying. Specifically, leaning to the outer slope line of the round roof each opening to do a shape like scissors "fork", that is, a ridge into two; leaning to the inner line of the round roof, each opening to cut one or two slots, which can ensure that the other ridge to maintain the standard spacing and parallel arrangement, in order to facilitate drainage (Figure 7 and Figure 8).

In addition, the small green tiles are pressed with square green bricks, which are generally pressed on the tile ridge and mostly arranged in two parallel circles along the end near the outer ring. In the two groups, one green tile is placed every other tile ridge, and the whole forms a circle parallel to the outer eaves. It is worth noting that there is a gap of exactly one green brick between the upper and lower rings.

Figure 7: Example drawing of small green tiles and bricks

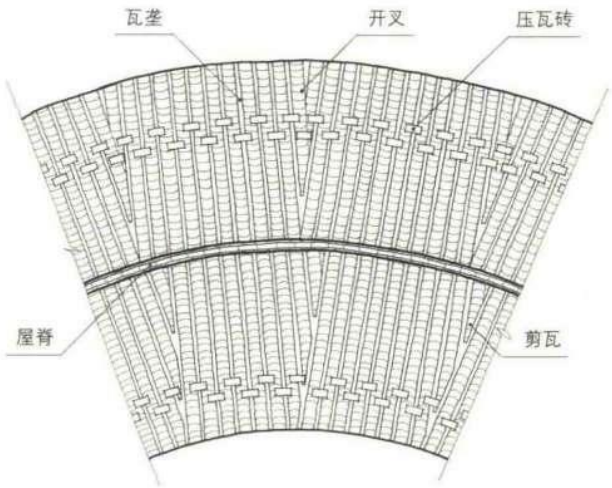


Figure 8: Schematic diagram of tile cutting (Huang, 2019)

Earthen Walls: Earthen walls include earthen walls that make up the bulk of the wall (some include stone footings, which are not a big part of the wall, so I won't go into that), doors and windows, etc.

Earthen Walls: As mentioned earlier, the walls of Nanjing Tulou are made by combining fine soil, sand and gravel, old wall mud lime and other materials mixed and rammed in different proportions, so they inevitably retain the physical basic properties of these materials (mainly texture, color and embodied sense of texture). From the point of view of the texture characteristics reflected, it shows a mottled sense of easy to produce cracks, and some particles of roughness, and due to the different proportions of the mixture of materials, the shape and distribution pattern of the cracks and texture of the walls reflecting the sense of age are also different. 5 earth buildings all reflect the rectangular array characteristics presented by the plate construction characteristics of the process of rammed earth, of which Zhenchang Building and Wenchanglou have the deepest cracks and heavier traces of the wall deterioration, while Zhenchang Building and Wenchanglou have the deepest cracks and heavier traces of wall deterioration, and Zhenchang Building has the deepest cracks. traces are heavier, and Zhenchang Building also shows a strong sense of mottling due to the peeling off of the wall soil on the surface skin, Ruiyun Building and Hechang Building's overall texture arrangement is relatively uniformly distributed horizontally and vertically, Ruiyun Building has some large cracks, and Buyun Building's overall reflection of the transverse texture lines have a tendency to become denser from bottom to top and the more the sense of the seam is more intense, while the longitudinal cracks are denser at the lower part of the upper part and looser at the lower part; from the point of view of its outer From the point of view of the color, it is mainly characterized by the combination of the reddish red of Nanjing red soil and the yellow of mud and sand, while appearing in the five earth buildings is manifested in different ways: it is mainly reflected in the red and yellow, yellow and red or red

and yellow; the mix of multiple materials of the earth wall (e.g., glutinous rice, brown sugar, egg whites, bamboo slices, etc.) makes the earth wall reflect more than the usual sense of firmness and durability of the earth wall after solidification and because of a certain degree of thickness, there is also a certain sense of thickness. The wall has a certain thickness and a certain sense of heaviness

The doors of the five earth buildings are wooden, and the door frames are made of green stone. Among them, the door frame of the square building Buyun Building is square, and the rest of the door frames are arched (which is influenced by the western architectural style), and above the stone door frame is the pierced square which resides inside the earth building but the shape is exposed. There are two stone steps right below the door, and two stone benches next to the stone steps, which are also two in number. The number 2 has an important place in traditional Chinese philosophical thought such as the idea of dichotomy, such as yin and yang, heaven and earth, life and death, black and white, male and female, hot and cold, soft and rigid and so on. The roots of this system of thought can be traced back to the I Ching. For example, in the I Ching, the number 2 represents the concepts of “opposition”, “division”, “change”, etc. (Wilhelm & Baynes, 2004).(Wilhelm & Baynes, 2011) In this context, the number 2 is applied to Tulou. Based on this, the use of 2 in the steps at the entrance of the Tulou building also includes the use of the cosmology and concept of life as mentioned above.

In addition, carving techniques are also used in the stone gates, as shown in the picture below, each earth building has Chinese characters based on the name of the earth building from the right to the left, of which the carvings of Buyun Building and Ruiyun Building are decorated in gold, Wochanglou in red, Zhenchang Building in brown, and Wunchanglou maintains the original color of the lapis lazuli (Table 4).

Table 4: Summary of Tianluokeng Tulou Gate

	Buyun Building, building in the clouds (place name)
	Hechang Building

	Ruiyunluo,
	Wenchang Mansion, a building built in the 18th century that serves as the home of the immortals
	Zhenchang Lou

The hole window: the hole window on the wall is generally arranged horizontally or almost horizontally, as shown in the figure below, from its distribution, the regularity but uneven. These holes and windows to a single or more into the organization into a relatively uniform arrangement, but the distance between the group and the group is not the same size; holes and windows are generally distributed in the 2 layer and three layers. As the area of the windows and holes in the wall occupies a small area, but causes the external painted concrete color to be relatively prominent, so the overall composition of the black and gray roof and yellow and red earth building of the embellishment (Figure 9).

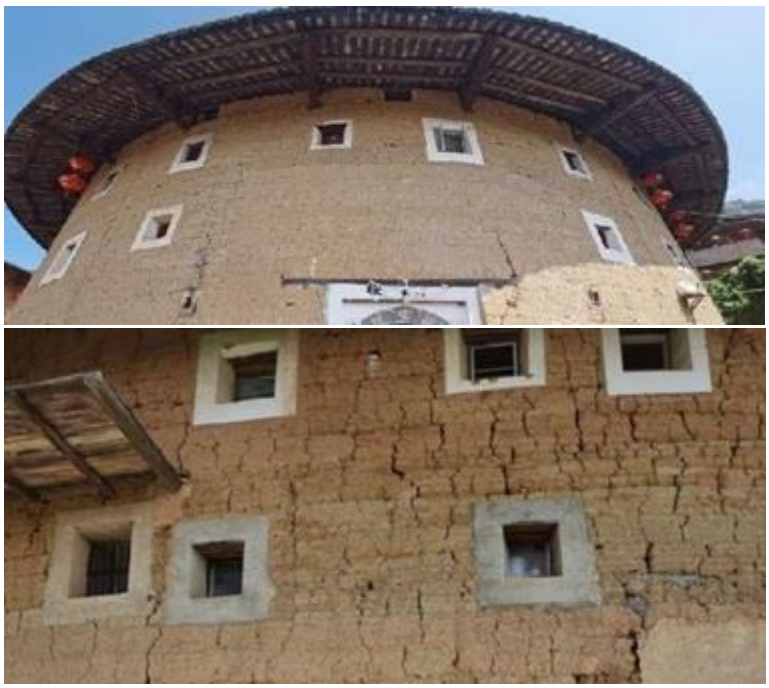


Figure 9: Cave windows of Tianluokeng Tulou

3.3 Internal wooden structure

According to Mr. Yang Hongxun's discussion of architectural archeology, residential building framework systems have typological characteristics and classifications.(Yang, 2008b) Mr. Liu Zhiping divided the forms of wooden frames into two types: “column and tie construction”（Chuandou） and “post and lintel construction”(Tailiang). “Chuan” and “Dou” originate from the folk and mean to put together. The term “frame beam” was coined to describe another structure that is visually different from “chuandou”.(刘致平, 2000)Internal wood structure refers to the wooden structure inside a building, which is usually used to support parts of the building such as walls, roofs and floors. According to Mr. Liang Sicheng's research and classification of “Building Style”, Chinese creative wooden components are divided into large wood structure and small wood structure systems.(Liang & Fairbank, 2005) In Nanjing Tulou, the wood structure is characterized by the combination of two structural systems: large wood and small wood. The large wood is the backbone of the wooden structure of ancient Chinese buildings, and is called large wood because of the large size requirements of the wooden components used in the buildings, such as beams and pillars. The small wood is the auxiliary parts, which are smaller in size. Overall, large timbers play a major role as load-bearing, connecting and other wood components, while the main function of small timbers is reflected in decorative or auxiliary functions. Both types of wooden structures utilize the traditional Chinese carpentry connection method of mortise and tenon. Embodied in the Nanjing Tulou, the wooden structure is built in conjunction with the foundation of the earthen wall (Figure 10).

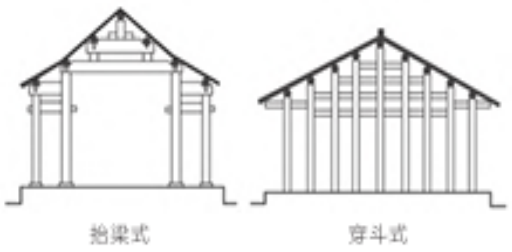


Figure 10: Post and lintel construction and column and tie construction (Su et al., 2023)

3.3.1 Large wood structures

The Nanjing Tulou is a multi-story building with 3-5 floors. The large wooden structures on each floor are consistent but differentiated due to their different functions, mainly divided into the top floor and non-top floors. The non-top floors mainly include wooden components such as columns, beams, and tiebeam, constructed using mortise and tenon-based building techniques, supplemented by bundling and stacking methods. The wooden components of the top floor are constructed using a through-tenon structure system, including penetrating tie, purlins, beams, and brackets.

Overall, Nanjing Tulou can be summarized as an evolution of the column and tie construction structure under the constraints of multi-story buildings and external load-bearing walls. (Wu, 2017a)In terms of the vertical load-bearing columns in Nanjing Tulou, they are generally not continuous but are interrupted based on the division requirements between floors, while maintaining the centerline of each column on the same vertical axis. These columns extend from the ground floor to the top floor and are connected to the main penetrating tie (the penetrating tie that primarily bears the roof load, with other upper-level penetrating tie named secondary penetrating tie), named as “hypostyle column” here. The hypostyle columns show a gradual decreasing trend from bottom to top (with some exceptions, such as the top floor of Buyun Building at 2.8 meters compared to 2.65 meters on the 2nd floor). The main through-beams (Named as through beams because they penetrate into the interior of the earthen walls, the beams are called through beams. The main through-beam on the columns primarily bears the load between floors,

hence it is named the main through-beam, while other through-beams are secondary through-beams) separate the columns from the earthen walls (Figure 11 and Figure 12).

Figure 11: Yongrong Building: Hekeng Village, Yang Town

Figure 12: Yude Building, Taxia Village, Shuyang Town

Starting from the first floor, the main through-beam extends outwards, with the extension of bracket connecting to the second-floor columns, connected by mortise and tenon joints, and surrounded by peripheral hypostyle columns to form a corridor. (As shown in hand drawing 1) The second-floor columns connect to the outer hypostyle columns and extend all the way to the top-floor main through-lintel using mortise and tenon joints. The second-floor main through-beam continues the extension of bracket from the first-floor main through-beam, with a smaller extension length than other floors. Near the courtyard side of the second floor's extension, there are columns connected by mortise and tenon joints, appearing as eaves or king posts depending on the floor level. If the floor has 3 levels, the columns are connected to the roof eaves purlins using mortise and tenon joints; if it is above 3 levels, a waist bracket is added, constructed with king post, small penetrating tie, and purlins using a column and tie style structure. The top-floor wooden frame is characterized by a unique face shape formed by penetrating tie, eaves columns, and hypostyle columns, connected by purlins to form the top-level framework. The structure is generally an eleven or nine purlins column and tie style wooden frame without raising the purlin. (Wu, 2017a) Horizontally, the entasis on the tops of the columns show a slight concave shape for supporting the main through-beam. Between columns, there are Dou tiebeams joints (different from the top column and tie structure of penetrating tie), forming a circle based on the enclosure nature of the building. The Dou tiebeams are spaced at the length of the house's width, with concave entasis at both ends to align with the columns. Above the Dou tiebeams are secondary through-beam, equal in length to the main through-beam

but with a smaller or equal cross-section. There are generally 2-3 of them, but 5-6 at the ancestral hall. Generally, mortise slots are opened on both sides of the flat entasis in the upper part of the through-beam for laying floorboards. In terms of shape, each floor's columns are relatively simple, retaining the original form of fir wood columns. At the first floor, there are cylindrical stone column bases made of bluestone; above the second floor, there are no column bases, and each floor has plinth stone connected to the columns in mortise and tenon form. The entasis of through-beams is flat at the top and bottom, with a curved profile on both sides and a straight profile top and bottom, connected between columns by mortise and tenon joints, sometimes also using bundling methods. The columns, tiebeam, and Dou tiebeams are interconnected and combined with earthen walls, bottom plates, and wooden wall surfaces to form the house. The upper part above the main penetrating tie on the top floor is usually covered with a ceiling but can be considered as a floor in practice as it is often used as storage space or bedrooms.

The components of the king posts and penetrating ties above the main penetrating ties are very simple, with two shapes: circular and rectangular, without any decoration or carving, and are joined using mortise and tenon joints. The dimensions of the purlins are much smaller than the columns, with a diameter of about 150 millimeters, connected to the king post using dovetail joints and arrayed according to the shape of the two-slope roof. In some earth buildings, there are purlin boards at the eaves purlins, intermediate purlins, and ridged purlins (Table 5 and Table 6). The method of constructing the eave columns in Nanjing Tulou is quite flexible, with three styles found: the groove in the middle of the upper end of the column supports “Tiaotou”(the end of “Tiao”); the groove on the side of the upper end of the column supports “Tiaotou”; and two columns with grooves on the side of the upper end combine to form a groove in the middle supporting “Tiaotou”. (Wu, 2017a). The eave column construction in Tianluokeng Earth Building is based on the single-eave nature of the earth building and adapted from traditional eave column construction, with the base resting on the main through-beam below and supporting “Tiaotou” upwards.

Table 5: Hand-drawn drawings of the wooden structures of earthen buildings

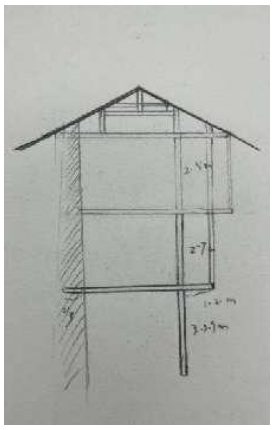
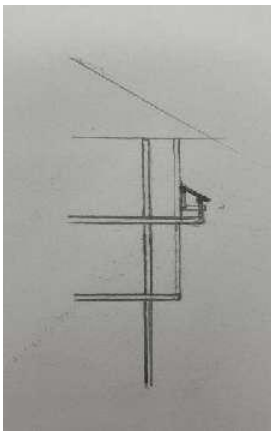
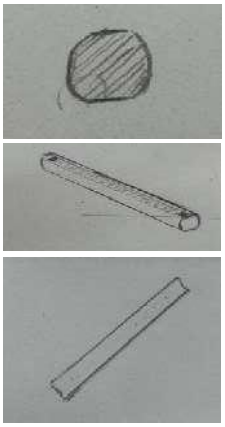
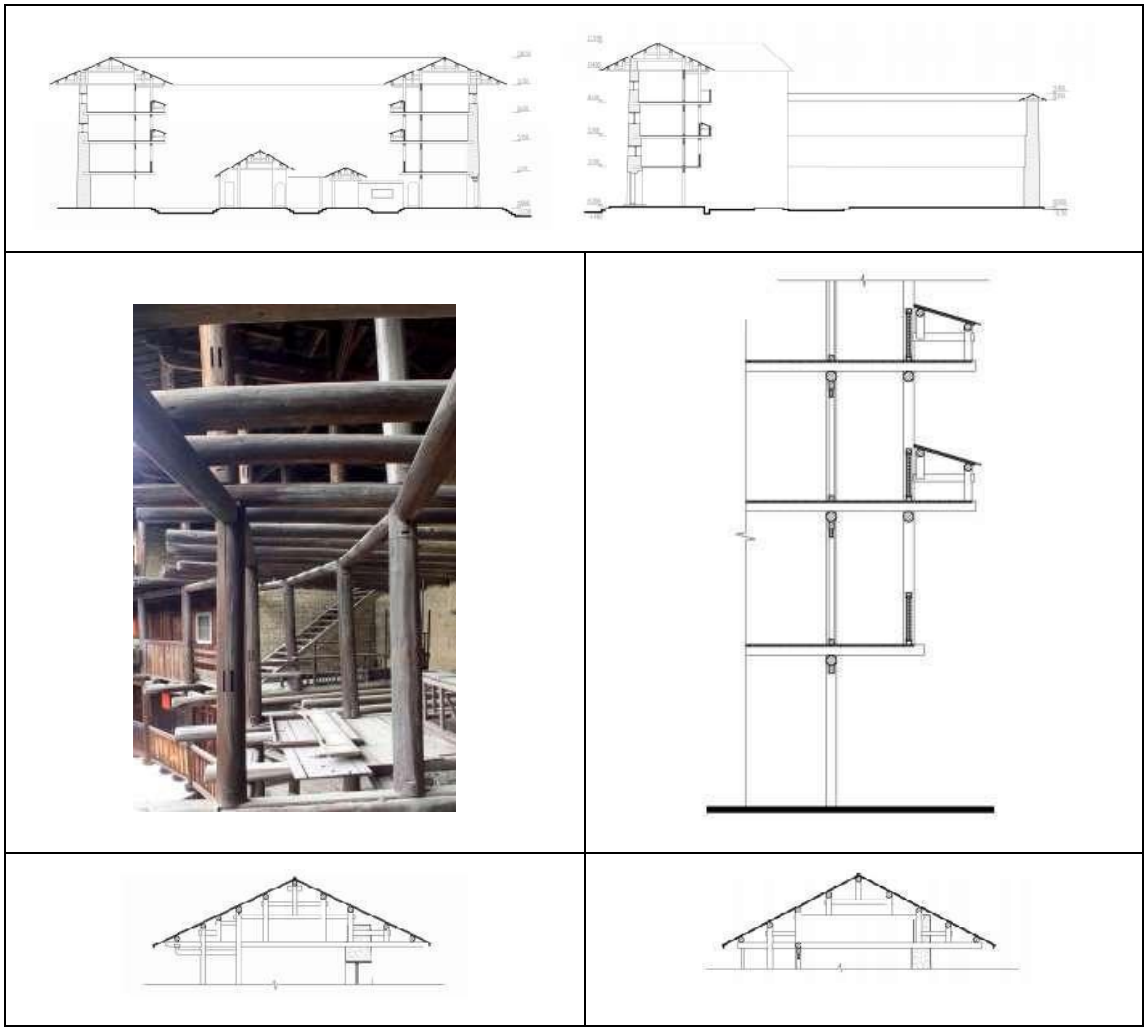
			
Hand drawing 1	Hand drawing 2	Hand drawing 3	Hand drawing 4

Table 6: Sectional drawing set of the interior wood structure of the Tulou building



Fence is divided into two categories according to the form, one for the board type, one for the straight latticework type (Table 7). One of them is the board type, which can be small boards firstly assembled into a large template with dragon and phoenix mortise and tenon, and then assembled by saving the edges and corners of the latticework. The straight latticework is characterized by the mortise-and-tenon technology of the combination of square timber and dingzhi (mortise and tenon big in and small out).

Table 7: Example diagram of a fence

	
Fence 1	Fence 2

3.4 Ancient architecture wooden components terminology

Wooden structure (large wooden structure) mainly plays a structural role in bearing, connecting, and assisting, including beams, brackets, purlins, column frames, rafters, and joint components of auxiliary beams and frames. Folk architecture does not have brackets.

Carpentry work: It is a very important craft and construction system in ancient Chinese architecture for thousands of years. It is called carpentry work because it is based on the system of large wood.

Trusses: In traditional Chinese architecture, it is a quantifier for the overall wooden frame of a house, usually referring to a flat structural body (Figure 13).

Figure 13: The illustrations of trusses

Eave Column: It connects the roof and is located at the outermost edge of the roof. There are generally two sets, but it depends on the type of building.

Hypostyle Column: Refers to columns inside the eave column but outside the central line.

King Post: In the components of ancient Chinese architecture's Wooden structure, it generally refers to the term for low columns.

Eave-supporting Column: In the components of ancient Chinese architecture's Wooden structure, it is used to support the overhanging roof of a house (the roof that extends beyond the wall).

Column Base: The base of a column, made of stone, used in traditional Chinese architecture to support the columns.

Plinth Panel: In traditional Chinese architectural construction, it connects with the ground and is generally the bottom component.

Beam: A component of ancient wooden structures in architecture, also known as “post,” is the main framework of a raised-beam building. The “beam” in buildings before the Yuan Dynasty is called “post,” and collectively known as “beam-post.” Through Beam: A component of ancient Chinese architectural wooden structures. The beam that connects the columns on the first and second floors is called the main through beam, while the one placed on top of the tiebeams is called the secondary through beam.

Tiebeam: A horizontal beam that connects two columns at their tops is called a lintel. It is named differently based on its position. In Nanjing Tulou, there are mainly two types of tiebeam:

Dou tiebeam: Used between the eave column heads.

Penetrating tie: Wooden components connecting the eave column and hypostyle column.

Purlin: In traditional Chinese architecture, purlins are also known as purline, purloyne, purling, or perling. During the Tang and Song dynasties, they were called “tuǎn.” Purlins are horizontal structural components in buildings that run parallel to the front of the building and perpendicular to the beams. The

rafters of the eaves are vertically supported by the purlins. In Tianluokeng Tulou, there are mainly three types of purlins.

3.4.1 Spatial layout of unit locations

Rooms on each floor are evenly arranged in a horizontal plane, encircling to form a ring-shaped or U-shaped structure. The rooms belong to the peripheral part of the entire earthen building. Due to the longitudinal planar connectivity of the wooden walls inside the rooms, the area of the rooms above and below is basically the same in the overall square or circular building (ignoring the tapering effect of the earthen walls from bottom to top). The ancestral hall and the entrance hall constitute the central axis (except for Zhenchang Building). In the case of perfectly circular buildings like Ruiyun Building and Hechang Building, the central axis overlaps with the radius of the circular building. For square buildings like Buyun Building, the central axis coincides with the central line, and for oval buildings like Wenchang Building, the central axis coincides with the short axis. The main entrances and ancestral halls of these buildings face directly southwest and northeast; while for the perfectly circular Zhenchang Building, its central axis also coincides with the radius, with its entrance hall and ancestral hall positioned directly south and northeast. Staircases, except for Buyun Building which has four staircases at the square corners, other round buildings have two staircases arranged at right angles to the entrance hall and ancestral hall, creating a special angular position. Adjacent to the rooms on the inside are corridors, with the first floor being a column-free corridor. The locations of corridors on the 2nd and 3rd floors are the same, but due to the overhanging beams above, the eave moves upward and inward towards the center of the courtyard. The courtyard and the earth building are concentric, formed by the enclosure of houses, creating an effect of an empty space from the courtyard ground to the eave. The courtyard ground is below ground level in the courtyard, based on the corridor ground it recesses downwards forming stone steps. Some sides of the steps have small staircases placed, some have bluestones laid out for walking up and down. The number of layers for small staircases is 1-2, arranged according to the importance of their location. (Table 8 and Table 9). Generally, the area around the ancestral hall is considered a core area, thus most small staircases are arranged more orderly there, followed by doors and staircases. Staircases may or may not have steps; small staircases may also be placed at house entrances. The arrangement of bluestones is more casual but still mainly around the ancestral hall, entrance hall, and staircases, with some scattered at house entrances. Additionally, Hechang Building has an extra layer beneath the stone steps, assembled in a circular pattern with cubic stones.

Table 8: Staircase design of Tianluokeng Earth Building

Building Name	The shape of the stone steps at the ancestral hall	The shape of the stone steps at the foyer	The shape of the stone steps at the staircase
Buyun building	2 levels of steps	1 level of step	At the staircases in the northeast and northwest, there is one 2-layer staircase at a 90-degree angle each.
Zhenchang Building	2 levels of steps	2 levels of steps	not have
Wenchang Building	limestone (colloquial)	1 level of step	The western part is bluestone, and the eastern part has 2 layers of steps
Ruiyun Building	1 level of step	limestone (colloquial)	not have
Hechang Building	not have	not have	not have

Table 9: Analysis of Tianluokeng Tulou Stone Steps

Building Name	Forms of placement	completeness	Integration level with the stone steps
Buyun Building	Small steps are placed quite regularly.	High	High
Zhenchang Building	The small steps are placed relatively regularly.	The ancestral hall is medium-high, and there is damage at the entrance hall.	Medium-high, with slight gaps
Wenchang Building	Bluestones are scattered, and there are angled steps at the door with a moderate level of regularity.	The level in the entrance is medium-low, the bluestone method at the ancestral hall is complete, the oval shape is irregular, and the completeness of the stone steps at the right staircase entrance is moderate.	High fitting at the entrance, moderate fitting between the right staircase entrance and the stone steps.
Ruiyun Building	The angled steps at the ancestral hall are moderately regular.	Medium at the ancestral hall, medium at the main entrance.	The ancestral hall is tall, and the main entrance is medium.
Hechang Building	not have	not have	not have

These spatial elements overall form a symmetrical effect with the central axis leading from the entrance hall towards the ancestral hall (although the entrance hall of Zhenchang Lou does not form a central axis with the ancestral hall, its rooms are still symmetrically arranged around the central axis). According to the principle of the central axis, except for the centrally located ancestral hall which holds a supreme position, the internal order within the family is relatively equal. This reflects that after the Hakka people migrated south and settled in the western mountainous area of Fujian, they lived in clusters for safety, prioritizing the defensive requirements of residential buildings over the internal hierarchical order of the family, advocating equality. This is a unique case in traditional Chinese residential architecture and is also the most captivating and interesting aspect of Fujian's round and square buildings (Table 10, Table 11 and Table 12).

Table 10: Nighttime interior view of Buyun Building

	
Rear Ancestral Hall Floor	Floor at front foyer

Table 11: Schematic diagram of the moving line of Tianluokeng Tulou

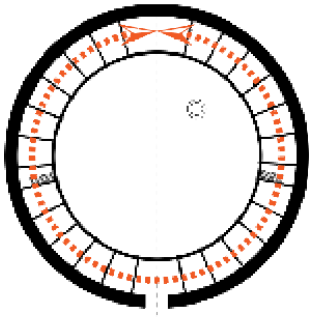
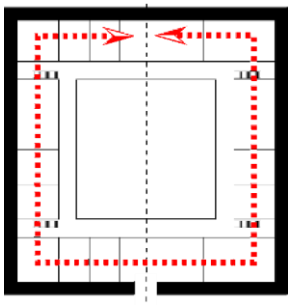
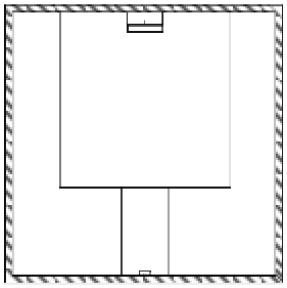
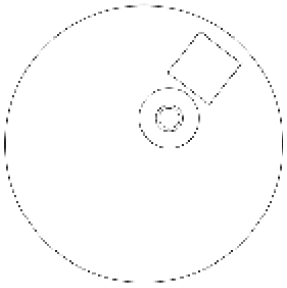
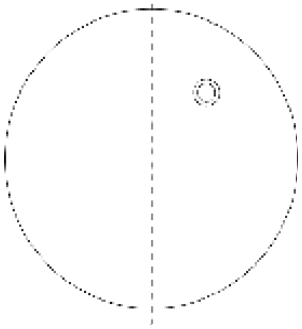
Type	Title
	Floor plan of Ruiyun Building
	Floor Plan of Buyun Building

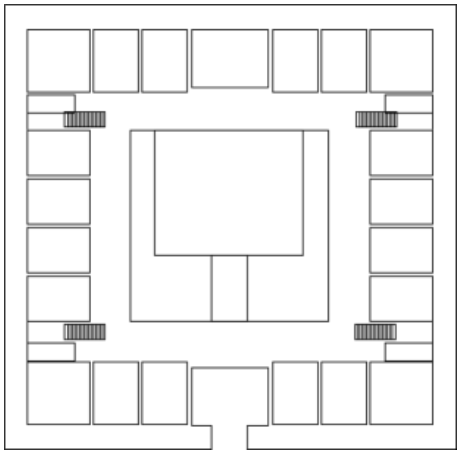
Table 12: Schematic Plan and Layout of Tianluokeng Earth Building

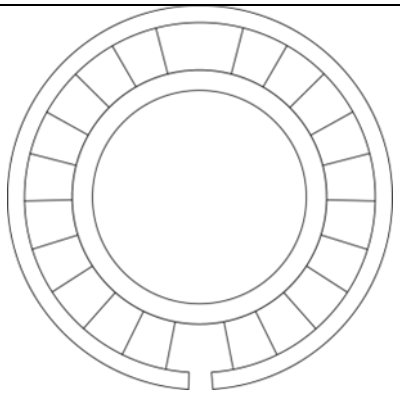
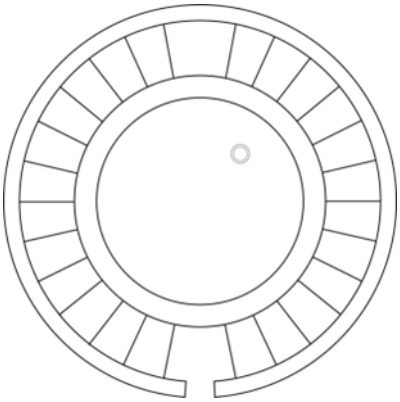
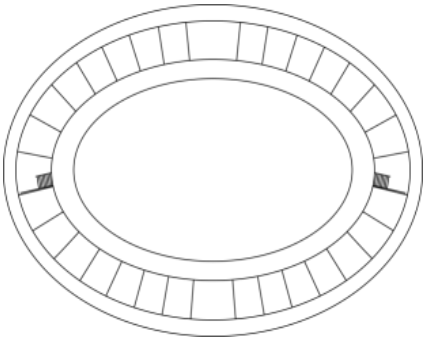
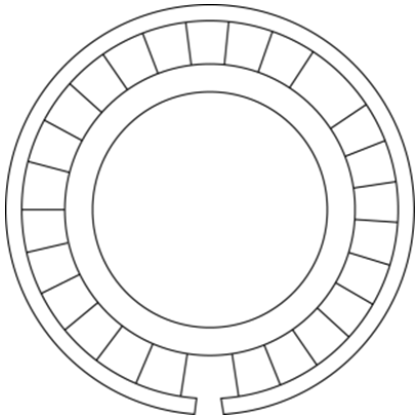
Tulou type	Courtyard floor plan	Distribution and Symmetry of Ground Space
Bunyun Building		The courtyard has a square overall shape and is symmetric along the central axis. The courtyard sinks below the first floor level, with two blocks from the ancestral hall to the entrance hall joined on the sunken courtyard and presented on the same plane. All blocks are symmetric along the central axis.
Hechang Building		The overall shape of the courtyard is square, symmetric along the central axis. The courtyard is flat overall, with a well and a small house in the upper right corner, asymmetric.

Ruiyun Building		The overall shape of the courtyard is square, symmetric along the central axis. The courtyard is flat overall, with a well in the middle of the upper right, without symmetry.

The internal spatial distribution and order of the Nanjing Tulou also exhibit centripetal characteristics. Looking at the architectural floor plans of the five Tianluokeng Tulous, the outer rooms of the circular Tulous (Hechang Lou, Ruiyun Lou, Zhenchang Lou) are fan-shaped, forming a ring shape as a whole. The contours of each room (including the ancestral hall and entrance hall), which are actually constructed by beams and columns, all point towards the center, creating a trend that guides the rooms and their constructions to gather towards the center. The square Buyun Building guides rooms and other spatial elements (including corridors, roofs, stairs, etc.) from four directions towards the courtyard through the main wooden components such as beams, columns, and lintels, forming a trend of gathering towards the center. The spatial element rules of the oval-shaped Wenchang Building are similar to those of the circular type, but its main wooden components, such as beams, columns, and lintels, do not directly point to the center of the courtyard. However, its overall closed-loop form causes the architectural spaces represented by rooms to have a trend of tightening towards the center of the courtyard, thereby achieving its centripetal nature. Additionally, due to the thick and enclosed outer earth walls of the five Tulous (with no windows on the 1st and 2nd floors, only small windows on the 3rd floor), and the entrance hall and corridors (the 1st-floor corridor is connected to the courtyard through stone steps, and the 2nd and 3rd-floor corridors are indirectly connected to the courtyard through stairs) linking to the open, well-lit courtyard inside. Therefore, it achieves a kinetic trend towards the central courtyard through the spatial path of the corridor in combination with stairs. Thus, overall, all five Tulous guide towards a trend of gathering towards the center of the courtyard with wooden components as the main guiding elements in combination with spatial paths (Table 13).

Table 13: Distribution of spatial elements of Tianluokeng Tulou (based on houses)

	Floor Plan of Buyun Building

	First floor plan of Hechang Building
	Ruiyun Building First Floor Plan
	First floor plan of Wenchang Building
	Floor Plan of Zhenchang Building

3.5 Artistic Techniques and Mediums

The study of architectural features expressed in artwork revealed a vast range of thematic concentration based on intended expression in regard to the given social era. While Hakka houses and clan dwellings seem to display similar themes in artwork, the houses of minority groups within indigenous cultures possess a greater link between the architectural element depicted and the social conditions and environment mediated (Durans 1998:81). An example of a She house in Ming Chung village uses a traditional Chinese ink landscape painting on rice paper to depict the original architectural element of verandas, which were used to create extra outdoor living space. This artwork was aimed to preserve and make tribute to She culture, but it is, in fact, an old element that has since been abandoned in new urban housing. This presents an interesting area for future ethnographic research into the She people and will preserve information regarding a culture and an element that is no longer in existence. This can be compared to artwork of TCDs in general, which is also aimed at cultural preservation but reflects the artist's desire to maintain an element still utilized in contemporary rural living.

In Hong Kong, a modern art piece was observed in a new village house using acrylic on canvas to portray an aerial view of the house, depicting the artist's identity as an educated fine arts graduate. In contrast to the traditional skills employed by village builders and Hakka women in wall and silk paintings in earlier examples, the declining popularity in TCDs results in a loss of cultural identity, and artwork rendered in any housing form of this genre will only reflect the ever-changing systems of Hong Kong and China rather than TCDs themselves. The actual social and economic changes in these rural areas over time and shifting trends in lower-class housing led to an evolution in the style and usage of artwork in or about TCDs. An example of an old wood carving in a Hakka house in Lo Wai reveals the typical artwork of the early and mid-20th century created by low-income villagers, which is now considered a precious folk art.

To investigate the artistic techniques and mediums employed in the artworks of TCDs, a method rooted in art history was implemented. Entailing an analysis into past and present artistic systems and traditions by considering the respective historical, social, and economic contexts in the locations where artists were located, the study revealed the variations in execution methods and materials according to cultural background and era. It was disclosed that the choice of artistic medium was influenced by the artist's social role.

3.6 Artworks Reflecting Architectural Elements

The variety and usage of decorative elements in vernacular architecture is a direct reflection of social conditions, cultural beliefs, and the aesthetic preferences of the dwellers' way of life. Since decoration represents a visual form of symbolic language, we can interpret it as an expression of the human spirit. Vernacular buildings in different areas may use similar decorative motifs and symbols, yet produce quite different overall effects. This could be due to the fact that the same symbol may carry different meanings in different cultures and the same mental image can be expressed in a variety of visual forms. The decorative elements used in Chinese vernacular buildings represent a visual crystallization of the Chinese people's view of the universe, social ethos and sentiment. These decorative elements, when spawned into

artworks done by urbanites on officials or gentry, can be interpreted as a romanticized version of the rural folks' sentiments. This is well known to be "escaping to the purity and harmony of the rural life," a vision that has been constantly idealized throughout the ages of Chinese history. This topic will be examined further through parallel symbol and motif studies between decorative elements of rural and urban architecture and the artworks of different periods.

3.7 Artistic Interpretation of Spatial Layout

The Chinese dwelling spatial layout often reflects the cosmological order and social organization of the past. Ancient cosmological beliefs reflecting the theory of yin and yang and the five elements of wood, fire, earth, metal, and water have influenced many aspects of Chinese culture, including architecture (Wilk in K.C. Chang, 1973). This includes building design based on cardinal orientation, with the existence of courtyards and adequate space between buildings to allow sunshine and wind to circulate. Various cosmological beliefs of the past have influenced the dwellings from various regions in China, often resulting in similarities with slight differences. The artworks done by Chinese painters have been based on the architecture found in these regions. An example would be the painting based on a traditional county government official's compound in Southern China during the Ming-Qing dynasty. This artwork reflects the layout based on the cosmological belief of the universe and also shows that the architectural original from that region reflected the beliefs of the past (Zeng, 1987).

In this study, we are focusing on the artworks done by Chinese painters and relating them back to the spatial concept in traditional Chinese vernacular dwellings. Most of the paintings have been done in the modern era, where the architectural originality has been preserved in some regions in China.

The artistic interpretation of spatial layout is a method for artists to reasonably present the spatial layout in a dwelling and represent their own point of view. This can be achieved through creating paintings, sketches, and even physical models to demonstrate the artist's point in an artistic way, compared to simply drawing out the spatial layout. This method has been found to be useful for explaining spatial concepts to others in seminars held by earlier researchers (Zainal et al., 2008; Zainal and Tateo, 2008; Zainal and Tateo, 2009).

3.8 Emphasizing Spatial Arrangement

The value of spatial arrangement in traditional Chinese dwelling design lies with its role as a nucleus from which social structure emanates through the organization of everyday activities. From a building theoretical perspective, dwelling activity can be categorized from public to private, formal to informal and so forth. However, the bifurcation of space into activities relies on a clear differentiation of purposes of space and the transformation of space making it unsuitable for activities which it was once intended. Primarily the case of modern day living in traditional Chinese style buildings would blur activity definitions due to contemporary lifestyle, ultimately resulting in a sagely home feel. Yet this does not detract from the model of ancient society and is an interesting point from which to determine the applicability of spatial arrangements the dwelling features to the society that occupies it. Public space is characterized as an extroverted, open and inviting space, it is a place for meeting, sharing and communal activities. In

traditional Chinese society the focus of public space would be the location of locals or kinsmen and would act as a sort of administrative area. The hall or tang in laymen terms, was a place for meetings, to entertain guests and for the head male to receive Taoist scholars and discuss local politics. Ancestor worship was also practiced in this area around an altar to the family ancestors. This would be intentional activity space and the tang's large, open and minimally furnished ambience is a representation of this. Family living adjusted what is deemed as public and was a slightly more secluded area. This was the activity space for mother and children and the center would be the kitchen area. An enclosed space ideal for play, it was also a place for a mother to tell family stories, usually attributed to local folklore from which Chinese design often interprets artwork and to educate their morals to module the children. This was an embodiment of nai li which has no direct translation but the concept of shaping an environment through achievement.

3.9 Incorporating Traditional Design Principles

The best way to create a modern work based on traditional Chinese design principles is to first gain an understanding of the concepts involved, and then abstractly adopt them to a new work. Traditional Chinese design is based on the concepts of Confucianism, Daoism, and other Chinese philosophical systems, and the common yin/yang contrast is often used to define a work's design. In recent years, a large number of Chinese architects and architectural researchers have sought to begin an exploration of traditional design principles and implement them into modern works. This was greatly facilitated by the establishment of the first set of modern design theories based on traditional Chinese design by Liang Sicheng and Liu Dunzhen in the 1930s. These early researchers sought to develop a method of learning from western design without directly imitating it. This was to first prove that China had a complete set of design theories of its own, and then to use these to reform modern Chinese architectural design. These theories are now being refined by a second generation of researchers, returning to China's traditional culture in order to find a new source of creative inspiration. One such example is a recent paper by the architect Yung Ho Chang, in which he attempts to derive a set of design principles from traditional Chinese dwellings and use them as a method to compare traditional and modern Chinese design.

3.10 Artworks Reflecting Spatial Concepts

Figure 2 Maitreya with Two Bodhisattvas: a celestial scene. The scene depicts a celestial paradise and the impending arrival of Maitreya, an event which is to bring a new era of the world cycle. The division of this paradise from the world of man is implied; the mural is an iconogram of Chinese cosmological ideas, which seeks to bring order to its troubled times by aligning the state to the process of renewal of the cosmos through the power of the saving hero. This it seeks to do in a universe divided into temporal and spatial settings, differing in qualities from the others, but never excluded from the oneness of the cosmos (Witkowski 1981: 109).

Beliefs on the cosmos are everywhere reflected in traditional architectural and interior artworks. For example, in many cultures cosmological ideas centre on an axial mundi, the central axis of the world, with the human abode mirroring the structure of the cosmos. The Dogon granary is built with a door that always faces east, toward the rising sun (Teague 1996: 48). The sun is here a symbol of the creative principle and

the ordering of the universe. This is echoed in Chinese architecture where the principle axis through a compound, a house, or a single room, is often identified as the yang line and is the key to the hierarchical ordering of spaces (Moore 2003: 181). The axis to the cosmos is also drawn in the mural on the rear wall of the Mogao cave number 61, dated to the Sui dynasty. In this cave, which is a sanctuary to the Maitreya cult, the Buddha is seated on a throne flanked by attendants, and celestial musicians, while bodhisattvas stand and sit in attendance.

Artwork is an expression of cultural beliefs, social attitudes and feelings, and is a mode through which tradition is handed down and transformed. When discussing traditional living environment, whether building or interior, artworks are serving as the reflection of beliefs and ideas in existent and virtual life, and are the re-presentation of thought and artifice of human beings. Artworks serving for traditional living environment reveal much information about the spatial concepts, in the form of ideas on the cosmos, beliefs in the supernatural power, and the pursuit of good luck and avoidance of ill fortune.

4. Conclusion

The dwelling as a whole constitutes a visual statement expressing a hierarchical ordering of spaces (p. 282). This is exhibited in the arrangement buildings of different function around the courtyard in accordance to their importance. The buildings themselves are constructed with a timber frame structure with walls as partition method (p. 283). The understanding of cosmological beliefs is best understood by analyzing the traditional Hui style of building in Anhwei Province (p. 283). A comparison of building positioning with I Ching diagrams reveals the adherence to cosmological principles in the layout of the buildings. Step by step analysis has shown the variety of cosmological principles reflected through different courtyard and building configurations in different regions of China.

In terms of spatial layout, the study has discovered that Chinese vernacular dwellings have exhibited significant understanding of the Chinese cosmological beliefs, and that they were manifested in the arrangement and configuration of architectural space. The enclosed nature of the courtyard with buildings disposed along its perimeter is undoubtedly among the most consistent and enduring feature of Chinese architectural design (p. 281). The courtyard and its adjacent rooms represent miniature representations of an ordered universe, and have symbolized the principles of hierarchical order, security, privacy, and the segregation of space between the sexes.

Traditional Chinese vernacular dwellings are often regarded as low in architectural and artistic value, due to the lack of understanding in their architectural and artistic achievements (p. 287). This study has argued that traditional Chinese vernacular dwellings possess the merits in both architecture and art. In terms of architectural features, it has been established that Chinese vernacular architecture is representative of an indigenous building tradition which has exhibited great regional diversity. Despite the diverse nature of Chinese vernacular dwellings in terms of the geographical difference, generally they share a common architectural language (p. 274). This is characterized by the use of wood as the main building material, bracketing systems to support the roof structure, and ceramic tiles as the principal roofing material (p. 275). It is this architectural language that gives Chinese vernacular buildings a cultural

continuity lasting over two millennia. Step by step analysis of the architectural elements has provided evidence of a correspondence between culture and built form. This is best represented in the universal plan type of a walled compound system.

4.1 Summary of Findings

It is hoped that this work will serve as an authoritative reference on the subject cited above for architects, architectural historians and those in fields related to Chinese traditional architecture and art. Throughout the development of history of exchange between the West and East, Chinese architecture has often been misunderstood and misrepresented. In periods of revivalism, this exchange has yielded a rather hybrid architecture that rarely reflects either culture accurately. This present work should provide adequate knowledge about Chinese traditional architecture and a basis for applying Chinese architectural methodology to modern architectural design practice in attempts to incorporate cultural factors and to define an identity for contemporary Chinese architecture. The understanding of cultural constraints and their impact on architectural design can benefit architects involved in preservation work, enabling them to decipher the hidden meanings behind architectural forms in traditional Chinese buildings and therefore to restore them more authentically. A comprehensive understanding of Chinese architectural and cultural history through this work may also facilitate cross-cultural studies and make comparisons between Chinese and Western architecture, avoiding the pitfalls of past misrepresentations. An understanding of the Chinese ways of building and the integration of architectural forms and artworks with cultural ideas should benefit those in the field of Chinese art, enabling them to produce work that is authentic and to comprehend the reasons cultural change has often led to the loss of traditional art forms. Different aspects of this work can also be used as a basis for future research or to further analyze the relationship between various dynasties and periods of Chinese history with the architecture that was produced.

Vernacular dwellings are fundamentally expressions of culture and lifestyle that date back for centuries. As such, they bear the imprint of the socio-economic order of their place and time. Traditional Chinese vernacular dwellings today have become a symbol of a disappearing way of life. In examining these dwellings, no attempt has been made to frame them in a nostalgia that is inappropriate for the lives of those who lived in them, nor to suggest that they represent a lost utopia for village life in China. Our findings should identify key aspects of the buildings, their spatial organization, and the artwork they contain, and explain them in terms of the behavior patterns and cultural constraints that governed their use.

4.2 Potential Applications of the Research in Contemporary Contexts

The detailed study of the architectural features and spatial layout of Nanjing's traditional earth buildings (Tulou) offers several potential applications, especially when considering contemporary contexts. These applications span across various fields, including architecture, urban planning, cultural preservation, and sustainable development. While these applications are not explored in detail within the research, they present promising avenues for future exploration and practical implementation.

4.2.1 Architectural Design and Innovation

The unique design principles and construction techniques of Tulou can inspire contemporary architects to incorporate traditional elements into modern buildings. This can lead to the development of hybrid architectural styles that blend traditional aesthetics with modern functionality. For instance:

Sustainable Building Materials: The use of local, natural materials like earth, wood, and stone in Tulou construction can influence modern sustainable building practices. Architects can explore the use of rammed earth and other eco-friendly materials to create energy-efficient and environmentally sustainable buildings.

Passive Climate Control: The thick earth walls and internal courtyards of Tulou provide natural insulation and ventilation. These passive climate control techniques can be adapted to modern buildings to reduce energy consumption and enhance indoor comfort.

4.2.2 Urban Planning and Community Design

The spatial layout of Tulou, with its focus on communal living and social cohesion, offers valuable insights for contemporary urban planning:

Community-Centric Developments: Urban planners can draw from the Tulou's design to create community-centric residential developments that promote social interaction and communal activities. This can help address issues of social isolation in modern urban environments.

Compact and Efficient Use of Space: The compact, multi-story design of Tulou maximizes the use of available land, making it a relevant model for high-density urban areas. Urban planners can adapt these principles to design efficient and space-saving residential complexes.

4.2.3 Cultural Preservation and Tourism

The study's findings can contribute to the preservation of cultural heritage and the promotion of sustainable tourism:

Cultural Heritage Conservation: Detailed documentation and analysis of Tulou architecture can inform conservation efforts to preserve these historical structures. This can include restoration projects that maintain the authenticity and integrity of Tulou buildings.

Tourism Development: Tulou buildings, with their unique architectural and cultural significance, can be leveraged to promote cultural tourism. Developing visitor centers, guided tours, and educational programs around Tulou can attract tourists and generate economic benefits for local communities.

4.2.4 Educational Programs and Research

The research provides a rich source of information for educational initiatives and further academic inquiry:

Architectural Education: Incorporating the study of Tulou architecture into architectural curricula can enrich students' understanding of traditional building techniques and cultural heritage. This can foster a new generation of architects who appreciate and integrate traditional principles into their work.

Interdisciplinary Research: The study's integration of architectural analysis with cultural and sociological perspectives can encourage interdisciplinary research. Scholars in fields such as anthropology, history, and environmental studies can explore the broader implications of traditional architecture in contemporary society.

4.2.5 Sustainable Development and Environmental Design

The principles underlying Tulou construction can inform sustainable development practices:

Eco-Friendly Construction: The use of local and natural materials in Tulou construction aligns with contemporary goals of reducing carbon footprints and promoting sustainability. Modern construction projects can adopt these practices to create environmentally responsible buildings.

Resilient Design: The robust design of Tulou, capable of withstanding natural disasters, offers lessons for building resilience into contemporary architecture. This is particularly relevant in areas prone to earthquakes and extreme weather events.

4.3 Future Research Directions

There are still many unanswered questions. This study has raised issues on the validity using a building before severe modifications, on changed use and changes to the original structures. There is a need to further clarify the original uses and structures of many building forms. Architectural documentation of vernacular dwellings, particularly from the Qing dynasty and earlier, is inconsistent or inaccessible. Though fieldwork is ideal, the use of historic maps and images (which are also an understudied resource) may be the only means of preservation for buildings that are either beyond or urban development. Step survey methodology is a stringent recording system, but for the greatest level of detail, building and small part excavation may be necessary.

The key question in Chinese architectural history in the past half-century has been focusing on the Chinese society's acceptance of foreign architecture, and whether the pursuit of modernization and new culture necessarily means the elimination of traditional culture and the built environment. This continues to be an important issue today. The last decade has seen a huge surge of interest in traditional Chinese architecture within Mainland China. Many academics, as well as the general public, have been re-evaluating traditional architecture in light of modern needs and looking for ways to preserve it. Literature on Architectural Conservation in China primarily deals with Buddhist monasteries, gardens, and Imperial architecture, leaving vernacular dwellings an understudied and poorly understood resource. The findings of this study have shown the wealth of information that can be gained through the study of traditional buildings of common people, and have also shown that there are methodologies and published resources available today that can be used to further this study.

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