


Article

Study on the Protection of the Spatial Structure and Artistic Value of the Architectural Heritage Xizi Pagoda in Hunan Province of China

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Abstract: Xizi Pagoda, or the pagoda for cherishing writing paper, is part of China's architectural heritage in culture, education, and rites. It symbolizes respect for books and ceremonies, aspirations for virtue and ideals, and hope for literati cultivation. This paper is the first comprehensive study based on the spatial structure and artistic value of the pagoda as rural stone architecture. It analyzes the shape, components, and decoration of typical Xizi Pagodas in Hunan Province, and studies the stress structure with finite element simulation software. This study delves into the science of the shape, structure and space, and the cultural and aesthetic connotations, and proposes protection and renovation methods. In conclusion, the architecture is decided by the cylindrical shape of the paper burning structure and aesthetics; it is also influenced by Hunan culture, which cherishes literature and ceremonies and values candor and optimism. The pagoda is a national art form with a unique role in enlightenment and education. Therefore, the protection and utilization of the pagoda can be approached from its spatial structure, artistic value, and cultural inheritance to facilitate the sustainable development of architectural heritage, environment, and culture, so as to build Xizi Pagoda into a new national brand.

Keywords: Xizi Pagoda; rural stone architecture; spatial structure; artistic value



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1. Introduction

This paper studies the tangible heritage Xizi Pagoda in Hunan from the perspective of spatial structure and artistic value, and delves into the conservation of Xizi Pagodas and the related intangible cultural heritage, such as the Xizi culture. As a structure with rich cultural and ritual connotations, the pagoda is a place for people to cherish paper bearing written or printed words by burning it (xi means to cherish and zi means words). Chinese people long had the tradition of worshiping words, which originated from Cangjie and his invention of Chinese characters. Legend has it that when Cangjie invented characters, millet poured down similar to heavy rain, ghosts cried at night, and dragons hid in caves out of fear. With the prevalence of imperial examination in Ming and Qing dynasties, writing became the main way to obtain a position in the court. Therefore, the ancient Chinese respected words and cherished paper due to the belief that such practice could bring good luck in the imperial examination.

Moreover, people believed in Wenchang Wang, the god of culture and literature. He also advocates the idea of respecting and cherishing writing paper, and that used paper shall be handled properly instead of being discarded or trampled. This explains why the Xizi culture prevailed in ancient China. The Xizi rite is the ritual of handling writing paper; namely, after the used paper was washed and dried, it would be put into the Xizi Pagoda

for burning, and the ash would be scattered into rivers or seas. Ancient Chinese were convinced that the water and the sky were connected, and paper thrown into the water could find its way back to Cangjie, the inventor of Chinese characters, and such a practice would enable the local culture to thrive and literati to prosper.

‘Traditional villages are not only the habitat for a community, but also the birthplace for culture and art, religious beliefs, folk customs and national spirit, as well as the ‘cultural matrix’ that helps with the interpretation of traditional Chinese culture such as literature, painting, architecture, art and religion’ [1,2]. As part of the architectural landscape in this ‘cultural matrix’, Xizi Pagodas are not only the representation of people’s belief in respecting writing paper, but also a symbol for access to the academic circle and a flourishing culture. They are widely distributed in China, mostly in rural areas of Sichuan, Hunan, Guizhou, and Fujian provinces, where they exist in large numbers as unique local architectural heritage. The Xizi culture has far-reaching influence with the rite preserved among overseas Chinese in Singapore, and Xizi Pagodas can be found in Singapore and even some Chinese communities in the US.

The Xizi Pagoda is a special form of ancient architecture that runs through the traditional Chinese culture. With urban and rural development in China, the number of Xizi Pagodas plummeted, and many of the remaining ones are damaged and in urgent need of rescue. However, there is little research on it in the field of architectural landscape across the world. Instead, current research on China’s pagodas both at home and abroad mainly focuses on their Buddhist origin and brief history, and the research object is within the Buddhist architecture system, neglecting non-Buddhist pagodas built in later years. In fact, the Xizi Pagoda is a form of ancient architecture that exists and develops on its own from so many perspectives, including cultural background, development history, spatial form, unique structure, artistic achievements, and architectural semantics. Despite all this, the Xizi Pagoda never received the attention it deserves in the field of landscape architecture. In the case study of ancient architecture, Xizi Pagodas are hardly at the center stage. Since many of them were built in the same shape as Fengshui pagodas, they continued to be ignored or mixed up for a long period of time.

At present, the Xizi Pagoda in Hunan Province is not yet fully documented. Through field investigation across the province, the authors found that most Xizi Pagodas no longer bear the function of burning paper, and a large number of them are either damaged or destroyed. Moreover, the local people seldom hear about their origin or the Xizi culture. Sadly, the culture and rites of cherishing words are gradually being forgotten and fading away. As people are once again embracing craftsmanship and cultural connotations in modern architectural landscape design, the Xizi Pagoda plays a significant role as a special type of traditional site furnishing buildings in China. Study on its spatial structure, artistic value, represented belief, and conservation is highly relevant to restoring the traditional tangible landscape heritage and passing on the craftsmanship and skills of the nation. Meanwhile, research and discussion on the Xizi Pagoda also facilitates the further spread and development of China’s outstanding traditional culture and beliefs, represented by ‘cherishing words’, ‘honoring culture’, ‘practicing ceremonies’, and ‘enjoying learning’.

First of all, this paper summarizes the background, current situation, purpose, and value of the architectural heritage Xizi Pagoda, highlighting the theme and objectives of the study. Secondly, this study delves into the spatial structure and artistic value of the Xizi Pagoda. With the Xizi Pagoda in Hunan as the research object, this paper conducts sampling analysis and field survey. With a spatial finite element model [3,4], the static and dynamic stresses of the pagoda are analyzed [5–7], its intrinsic aesthetics and cultural connotations are explored, and protection methods are put forward. Research results show that the aesthetic form, spatial structure, and cultural connotations of the Xizi Pagoda are interrelated, which together speaks to China’s traditional scholarly vibe featuring ‘benevolence’, ‘respecting teachers’, ‘valuing education’, ‘enjoying learning’, and ‘gentleness’.

Finally, according to the above research results, the authors go further and conduct a comprehensive discussion on the cultural value of the Xizi Pagoda as well as its protec-

tion and utilization. We can preserve the Xizi Pagoda and carry forward the Xizi culture from the tangible and intangible perspectives by structure repair, decoration restoration, and overall landscaping. Based on international principles, conventions, and cases [8], this study proposes methods for conserving the Xizi Pagoda and carrying forward the Xizi culture, which has unique theoretical value and relevance for the protection of global architectural and cultural heritage, as well as the adaptive use and development of traditional structures.

As a study on the protection of the tangible heritage of the Xizi Pagoda, the questions and objectives of the research are as follows: First, the authors carried out systematic and comprehensive research on the spatial structure and artistic value of Xizi Pagodas in Hunan. What are the defining features of their spatial structure and artistic value? Second, this paper carries out an in-depth analysis on Xizi Pagodas in Hunan from the aspects of spatial structure, functions and characteristics, shapes and style, cultural connotations, architectural stress, artistic value, as well as protection and utilization. Why has the Xizi Pagoda survived for hundreds of years? What are the cultural connotations and craftsmanship contained in the artistic value of the Xizi Pagoda? Third, this paper conducts a detailed analysis and discussion on the matter of Xizi Pagoda protection. What are the measures of restoration and preservation of the architectural heritage Xizi Pagoda and the methods of inheritance and utilization of the Xizi culture?

2. Literature Review

All discussions on the Xizi Pagoda as architectural heritage are conducted among Chinese scholars, but there are few dedicated studies so far. As the venue for honoring Xizi culture and praying for blessings, Xizi Pagodas were mostly built during the Ming and Qing Dynasties [9]. Most of them are located by the waterside, where it is convenient to dispose of paper ashes and sending them to the sea, or near academies, ancestral halls, village entrances, and temples, where plenty of writing paper is produced [10].

In terms of artistic value, the artistic features of the Xizi Pagoda embody China's traditional aesthetic standards, such as the combination of square and circle, order and hierarchy, as well as symmetry and balance. In terms of culture and philosophy, the Pagoda has been influenced by multiple cultural factors, including Confucianism, Buddhism, and Taoism [11]. During the Second World War, a large number of cultural relics and ancient buildings were destroyed or damaged to various extents, and so were many Xizi Pagodas, which haven't been fully preserved.

Over the past 30 years of reform and opening-up, China committed to protecting cultural heritage, while the Xizi Pagoda as cultural heritage never received enough attention. After the 2008 Sichuan earthquake, the government began to salvage the damaged cultural relics in the disaster-stricken area [12]. Meanwhile, China carried out the Third National Cultural Relics Survey, and many precious Xizi Pagodas were saved, ushering in a stage of steady preservation. In recent years, as people increasingly valued the Xizi Pagoda as cultural heritage, research teams took field shots, obtained the measurement on the spot, established 3D digital modeling with data [13], and conducted digital art restoration in accordance with the size of the building [14]. However, current research on the Xizi Pagoda mainly focuses on its history, culture, or rites, and there is a lack of comprehensive research on its structural stress, architectural techniques, spatial structure, artistic value, and heritage protection.

As part of Chinese local architectural heritage, it is worth pondering how to effectively protect the historical sites of the pagoda. Conserving folk architecture and its surrounding landscape in combination with local culture is what scholars from across the world are working on [15]. As early as 1964, the Venice Charter discussed the tangible and intangible conservation of monuments through adaptive reuse [16] (ICOMOS 1964, Article 5). Plevotes and Van Cleempel proposed that it is necessary to protect architectural heritage and keep those structures alive instead of serving as museums, which is one of the key

ways to reuse local folk buildings and other architectural heritage [17] (Plevotes and Van Cleempoel, 2012).

The subsequent Charter on the Built Vernacular Heritage in 1999 also mentioned the importance of ‘adaptation’ and ‘reuse’: adaptation and reuse of vernacular structures should be carried out in a manner that will respect the integrity of the structure, its character, and form, while being compatible with acceptable standards of living. Where there is no break in the continuous utilization of vernacular forms, a code of ethics within the community can serve as a tool of intervention [18] (ICOMOS 1999, Adaptation).

The Burra Charter puts forward ‘adaptive’ protection and innovative use of historical heritage for the conservation of historical structures (ICOMOS 2013, Article 21 and 22). In addition, the Burra Charter states that to meet current social needs, small-scale demolition and renovation of historical sites can be conducted as appropriate [19]. (Australia ICOMOS 2013, Article 15.3). In 2000, ICOMOS China unveiled the Principles for the Conservation of Heritage Sites in China as a professional guide for the conservation of historical sites. This document advocates 15 principles, such as ‘protecting the original site, minimizing intervention, carrying out routine maintenance, conserving existing physical objects and historical information, applying technology as required, keeping to certain aesthetic standards, preserving the environment for cultural relics, avoiding rebuilding structures that no longer exist, highlighting physical remains in archaeological work and preventing disasters’ [20] (ICOMOS China 2015, Articles 1–15). The above-mentioned charters and principles provide the basis and guidance for the conservation of the architectural heritage Xizi Pagoda in this paper.

At present, there is a lack of systematic and comprehensive review and research on the Xizi Pagoda on a global scale. From 2009 to 2023, a total of 40 papers on the Xizi Pagoda were included in the China National Knowledge Internet, or CNKI, including eight master’s theses, nine related studies on Xizi Pagodas in Sichuan and Chongqing, three in Hunan, one in Guizhou, and one in Zhejiang. The available literature mainly focused on five aspects: the origin and history of the pagoda, artistic features, the customs and common practices of cherishing writing paper, and the image and modern value of the pagoda.

A literature review on the Xizi Pagoda reveals the lack of research on its artistic value and spatial structure, and the research on the protection and utilization of Xizi Pagodas in Hunan Province is far from systematic. This paper is an interdisciplinary study of the spatial structure and artistic value of the Xizi Pagoda in Hunan, which is helpful for the protection and development of the pagoda as tangible heritage, the spread and development of the Xizi culture, and the conservation of the folk customs of cherishing writing paper.

3. Research Methodology

This paper studies the spatial structure and artistic value of the Xizi Pagoda in Hunan by adopting a field investigation for a case study. The team conducted a field investigation on a total of 58 Xizi Pagodas in Hunan, covering central Hunan (Changsha and Wangcheng), southern Hunan (Guiyang, Jiahe and Linwu), and southwestern Hunan (Shaoyang, Longhui and Jianghua). Hunan has a time-honored history in education, which dates back to the pre-Qin period (from the Paleolithic age to 221 BC), developed in the Song Dynasty, and reaching its peak in the Yuan, Ming, and Qing Dynasties. During the Ming and Qing Dynasties, there were 429 Jinshi, or Imperial Scholars, in Hunan, accounting for 56.2% of the national total [21]. Therefore, Hunan boasted a scholarly vibe, and the Xizi culture was passed down. A large amount of cultural and educational architectural heritage emerged, such as academies, temples, schools, and Xizi Pagodas, which were well preserved. Therefore, this paper chooses Xizi Pagodas in Hunan as the main research object. During the field investigation, firstly, tools such as digital cameras, drones, and laser diastimeters were used to photograph pagodas and obtain the measurement. Due to technical limitations, there might be slight deviations in terms of detailed measurement. Secondly, local residents and government staff were interviewed. Lastly, first-hand materials, such

as video, data, interview recordings, and notes, were sorted out. In this paper, 16 typical Xizi Pagodas are selected for case study.

After obtaining the on-site photos, first-hand materials, and detailed data of Xizi Pagodas, the authors analyze the stress of the pagoda with finite element simulation software. The type of stress of the Xizi Pagoda is relatively limited, but the overall distribution of internal forces is complicated by structures such as openings and eaves. To study the structural distortion and internal force distribution of different Xizi Pagodas, this paper introduces the finite element software DIANA (10.5), and establishes different numerical models based on the structure of typical Xizi Pagodas in Hunan.

Field investigation shows that small-sized Xizi Pagodas are usually no more than five meters high; they have light self-weight, and will not be easily affected by wind load, making it impossible to conduct targeted mechanical analysis. That is why only high-rise pagodas are analyzed in this paper. The numerical model built on survey results is a five-story pagoda with a height of 10.562 m and an inclination angle of 86.2°. According to different forms of the underside of Xizi Pagodas, models with regular quadrilateral, hexagonal, and octagonal undersides were established, respectively. By analyzing their structural distortion and internal force distribution [22], this paper delves into the reason why Xizi Pagodas survived for over a century, and identifies locations for further protection and repair.

Meanwhile, this paper discusses the belief, culture, and philosophy contained in the Xizi Pagoda through a literature review. Firstly, the authors went through 23 journal articles on the Xizi Pagoda and the Xizi culture published on CNKI from 2008 to 2022. As the research on the Xizi Pagoda is still in its infancy and there is a lack of papers in this field, the search scope was expanded to architecture, art, history, and sociology. The authors searched for keywords such as 'Chinese pagoda', 'traditional architecture aesthetics', 'traditional Chinese patterns', and 'Hunan Culture', and resorted to books, papers, reviews, and journal articles. By comparing 53 works, reports, and periodical articles, the authors further analyzed the shapes and styles, spatial structure, and aesthetics of the Xizi Pagoda.

4. Research Findings

4.1. Structure, Shape, and Artistic Value of the Xizi Pagoda

For the Xizi Pagoda, shape is the external representation and structure is the internal framework, while artistic value epitomizes its cultural connotations. The spatial form, material structure, and artistic components of the pagoda are co-dependent, interconnected, and complementary to one another.

4.1.1. Structure, Shape, and Combination of Components

The Xizi Pagoda in Hunan province is a ritual place to cherish paper bearing written or printed words, and is also a representation of people's belief in respecting writing paper. The Xizi Pagoda is mainly built of stone, which is resistant to pressure, fire, and moisture. The outer wall is built with layers of stones, while the foundation bed and vertical shaft are solid structures. 'The inside of the pagoda is a hollow structure from bottom to top in a cylindrical shape' [23]. The hollow main body of the pagoda is installed with openings and arches in different directions, enabling people to burn paper, ensure ventilation, and clean paper ashes. The spatial structure of the Xizi Pagoda, which features the enclosed main body, hollow inside, and staggered openings, perfectly meets the demand for burning writing paper (Figure 1).

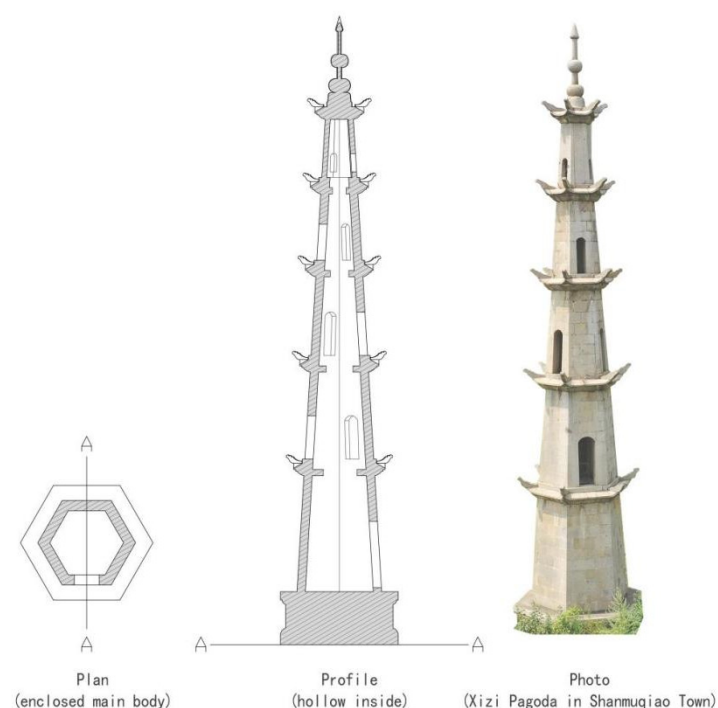


Figure 1. Structure diagram of the Xizi Pagoda (image source: made by the author).

Field investigation shows that most of the Xizi Pagodas in Hunan were built during the Ming and Qing Dynasties, and their planes are in a symmetrical shape, dominated by hexagonal, and followed by quadrilateral and octagonal (Figure 2) (Table 1). Built in the sixth year of Emperor Guangxu's reign (1880), the Xizi Pagoda in Hebian Village, Yankou Town, Longhui County, Shaoyang, introduced the quadrilateral and hexagonal shape (Figure 2D). This pagoda has three floors: the first floor is quadrilateral in its plan, while the second and third floors are hexagonal. Such innovative structures have diversified the plane shape of Xizi Pagodas in Hunan.

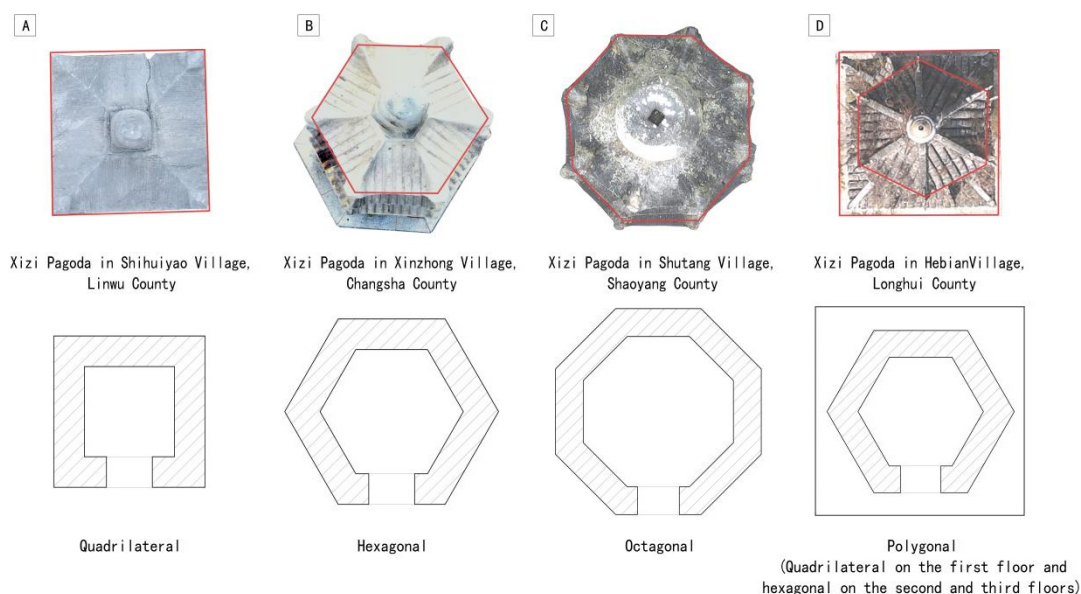


Figure 2. Plan of the Xizi Pagoda (image source: made by the author).

Table 1. Basic information of some Xizi Pagodas in Hunan.

Region	Location	Time of Construction	Shape of Plane	Side Length of Plane (m)	Area of Plane (m ²)	Size	Number of Floors	Overall Height (m)	Height of Foundation Bed/Main Body/Vertical Shaft (m)	State of Conservation (Complete/Relatively Complete/Damaged/Severely Damaged)
Jiahe County, Chengzhou	Xizi Pagoda in Chujiang Village	Emperor Jiaqing's reign (1814)	Quadrilateral	1.17	2.74	Small	1	3.03	0.44/1.64/0.89	Damaged: missing vertical shaft
	Xizi Pagoda in Qingshan Village	Emperor Jiaqing's reign (1816)	Hexagonal	-	-	Small	3	4.30	0.7/3.75/0.4	Severely damaged: damaged vertical shaft and tilted main body
Guiyang County, Chengzhou	Xizi Pagoda in Shang-longquan Village	Emperor Daoguang's reign (1821)	Quadrilateral	0.62	0.77	Small	1	1.62 (re-mained height)	0.1/1.27/0.25	Damaged: missing vertical shaft
Region	Location	Time of Construction	Shape of Plane	Side Length of Plane (m)	Area of Plane (m ²)	Size	Number of Floors	Overall Height (m)	Height of Foundation Bed/Main Body/Vertical Shaft (m)	State of Conservation (Complete/Relatively Complete/Damaged/Severely Damaged)
Guiyang County, Chengzhou	Xizi Pagoda in Chenxi Village	Emperor Tongzhi's reign (1862)	Hexagonal	0.9	2.10	Small	3	5.68	0.59/4.05/1.04	Complete: partly damaged carvings
	Xizi Pagoda in Shuangjiang Village	Emperor Guangxu's reign (1875)	Hexagonal	0.8	1.66	Large	5	9.30	1.46/7.3/0.57	Relatively complete: partly missing inscription
	Xizi Pagoda in Maofu Village	Emperor Daoguang's reign (1850)	Hexagonal	0.84	1.83	Small	3	5.65	0.1/4.29/1.26	Relatively complete: partly damaged carvings
	Xizi Pagoda in Zhongliu Village	(1875) Emperor Guangxu's reign (1875)	Hexagonal	1.02	2.70	Small	2	3.60	0.59/2.4/0.61	Relatively complete: partly missing inscription and damaged main body

Table 1. Cont.

Region	Location	Time of Construction	Shape of Plane	Side Length of Plane (m)	Area of Plane (m ²)	Size	Number of Floors	Overall Height (m)	Height of Foundation Bed/Main Body/Vertical Shaft (m)	State of Conservation (Complete/Relatively Complete/Damaged/Severely Damaged)
Linwu County, Chengzhou Jianghua County, Yongzhou	Xizi Pagoda in Shihuiyao Village	Emperor Daoguang's reign (1839)	Quadrilateral	1.0	2.00	Small	1	2.59	0.70/1.27/0.62	Relatively complete: partly missing inscription
	Xizi Pagoda in Shijia Village	Emperor Qianlong's reign	Hexagonal	0.5	0.65	Small	3	4.05	0.81/2.36/0.88	Relatively complete: partly missing components
	Xizi Pagoda in Daxu Town	Early Qing Dynasty	Hexagonal	1.26	4.12	Large	5	-	-/10.8/-	Complete
Changsha County, Changsha	Xizi Pagoda in Xinzhong Village	Emperor Daoguang's reign (1830)	Hexagonal	0.68	1.20	Small	2	4.50	0.81/2.7/0.99	Complete
Wangcheng District, Changsha	Xizi Pagoda in Chating Town	Emperor Daoguang's reign (1838)	Hexagonal	-	-	Large	5	12	0.85/11.15/-	Damaged: missing vertical shaft
Region	Location	Time of Construction	Shape of Plane	Side Length of Plane (m)	Area of Plane (m ²)	Size	Number of Floors	Overall Height (m)	Height of Foundation Bed/Main Body/Vertical Shaft (m)	State of Conservation (Complete/Relatively Complete/Damaged/Severely Damaged)
Longhui County, Shaoyang	Xizi Pagoda in Shan-muqiao Town	Emperor Guangxu's reign (1887)	Hexagonal	1.18	18	Large	5	15	1.28/11.7/2.20	Complete
	Xizi Pagoda in Xinhua Village	Emperor Daoguang's reign (1843)	Hexagonal	0.53	3.0	Small	2	4.0	0.6/2.04/1.36	Relatively complete: partly missing inscription on the main body
	Xizi Pagoda in Hebian Village	Emperor Xianfeng's reign (1851)	Quadrilateral + Hexagonal + Hexagonal	12.8	-	Large	3	14.5	-	Relatively complete: partly damaged carvings
Shaoyang County, Shaoyang	Xizi Pagoda in Shutang Village	Emperor Xianfeng's reign (1851)	Octagonal	0.55	1.46	Large	5	7.05	0.45/6/0.6	Relatively complete: partly missing components

The facades of the Xizi Pagoda tend to be odd-numbered and are large at the bottom and small at the top (Table 1). The Xizi Pagoda includes small-sized and large-sized ones (Figure 3). Small-sized pagodas mostly have one or three floors, with a total height of 2.0–6.0 m. Due to the small building volume, to reach a balanced proportion, the foundation bed is relatively low with a height of 0.40–0.81 m (Figure 4). The height of each floor is 0.8–1.6 m (Figure 4) and that of the vertical shaft is 0.62–1.04 m (Figure 4). Large-sized Xizi Pagodas usually have five or seven floors with a total height of 9–15 m (Fig-

ure 4). The height of the foundation bed depends on that of the main body, and is generally 0.85–1.46 m, with each floor being 1.46–2.23 m (Figure 4) high and ‘the vertical shaft being 1.0 m high on average’ [24]. The shape of the vertical shaft originated in ‘stupa’ in Indian Buddhist architecture, which presents sacredness and solemnity (Figure 4) [25].

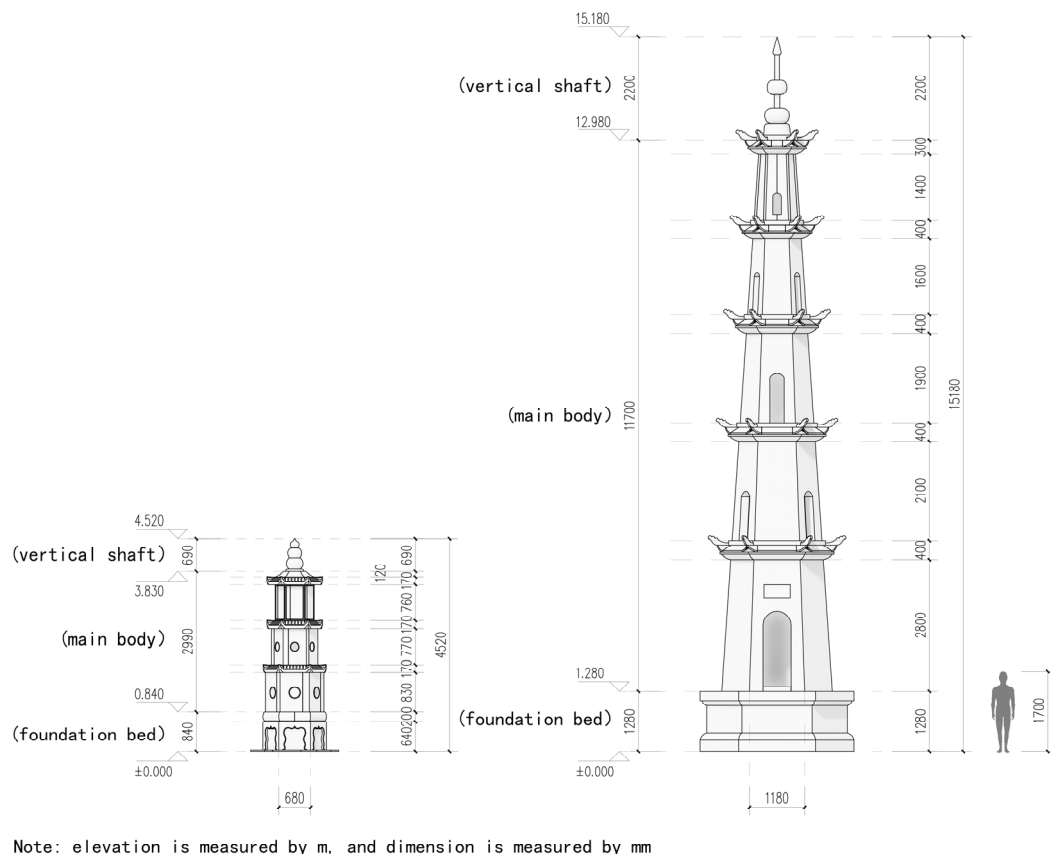


Figure 3. Small-sized and large-sized Xizi Pagoda (image source: made by the author).

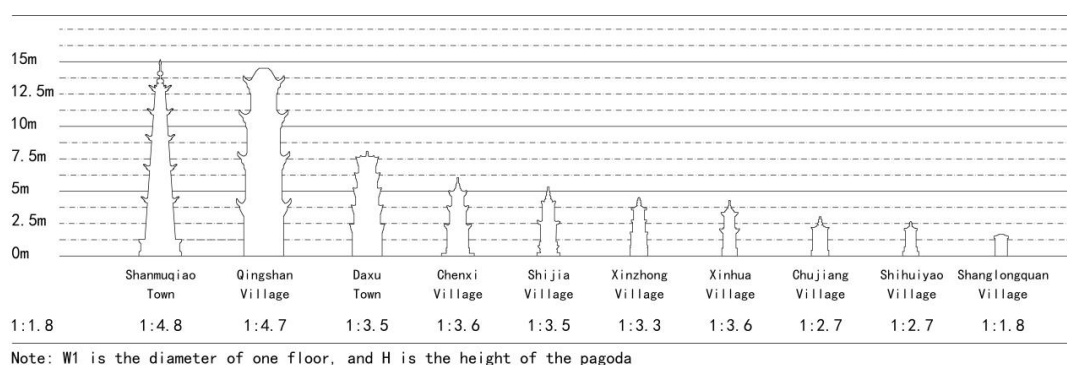


Figure 4. Facade and proportion diagram of small-sized and large-sized Xizi Pagodas (image source: made by the author).

Field investigation on the status quo of 58 Xizi Pagodas shows that 30 of them are completely damaged (51.7%), and 12 are severely damaged and difficult to repair (20.6%). A total of 16 Xizi Pagodas (27.7%) are well conserved, typical in shape and unique in style and structure, so they are selected for case study. Specific data and related information can be found in Table 1.

A Xizi Pagoda mainly includes three parts: foundation bed, main body, and vertical shaft (Figure 3). As the bearing base of the pagoda, the foundation bed consists of the

abutment and the pedestal. ‘This part is generally made of rammed earth wrapped with bricks and stones, providing protection for the foundation and resistance to water and moisture’ [26]. Most of the abutments are quadrilateral, and some are hexagonal or octagonal. They are simple, plain, and durable, with no complicated decorations or patterns. The pedestal falls into two categories: plain square pedestal (Figure 5A1,A2) and Sumeru pedestal (Figure 5A3,A4). The former is built by combining and stacking stones, and is solid in texture and plain in style, similar to the abutment.



Figure 5. Foundation bed of the Xizi Pagoda (image source: made by the author).

As a major type of Buddhist architecture, the Sumeru pedestal symbolizes sacredness and firmness [27]. A typical Sumeru pedestal includes six layers, which are known as Guijiao, Xiafang, Xiaxiao, Shuyao, Shangxiao, and Shangfang from bottom to top. The Sumeru pedestal of a Xizi Pagoda is a simplified and improved version of the traditional one, which retains Shangfang and Xiafang, with Shuyao in the middle. The facade is the shape of the Chinese character gong, with two big ends and a small middle. For the Xizi Pagoda in Xinzhong Village, Changsha County, only Shangfang was kept, and its bottom is next to Guijiao, while the rest is all simplified (Figure 5A3).

The main body is part of the pagoda that is above the foundation bed and below the vertical shaft, which consists of the eave, cornice, ladder, opening, and ceiling. Most of the eaves are carved with stone and not very protruding, providing shading, rainproofing, and decoration. The eave of the Xizi Pagoda in Leshan Village, Longhui County, Shaoyang is covered with delicate grey tiles, which helps drainage and moisture prevention, and presents unique beauty. On the eave of the Xizi Pagoda are decorative cornices with sharp angles. The cornice of the Xizi Pagoda in Chating County, Changsha is egret-shaped (Figure 6A1), while that of the pagoda in Maofu Village is shaped as a cirrus cloud. The shapes of these cornices are inspired by nature (Figure 6A3). Some Xizi Pagodas have ladders with folded inwalls, which save space and ensure lighting inside.

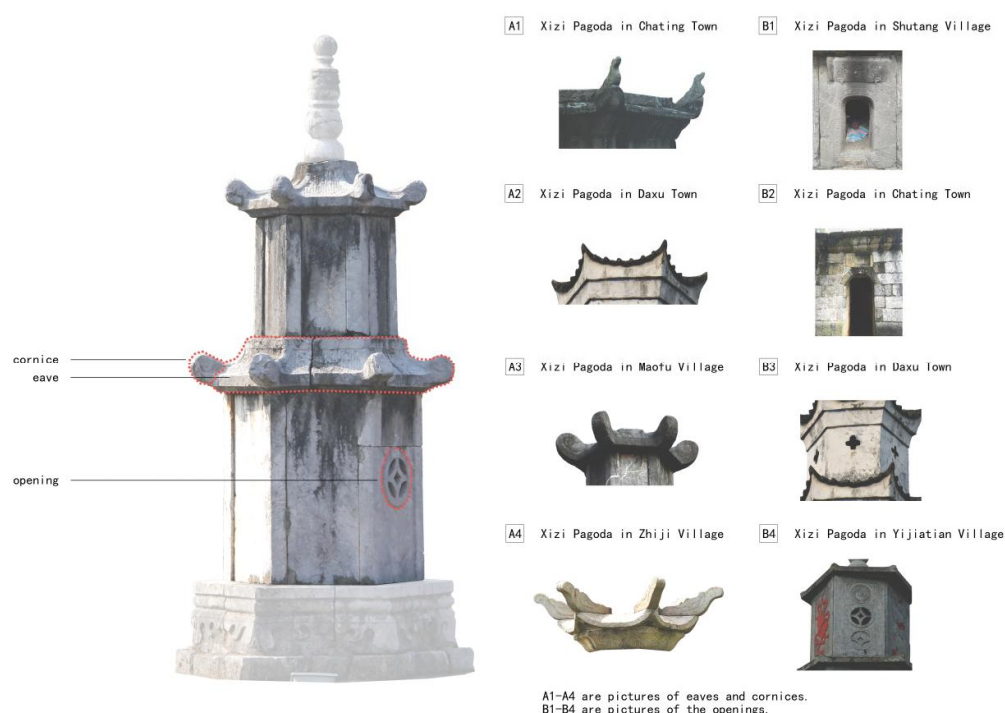


Figure 6. Main body of the Xizi Pagoda (image source: made by the author).

As people burn writing paper in the pagoda, there are openings for paper burning and smoke expelling. In traditional Chinese philosophy, since the south belongs to fire (one of Wuxing, or five phases), the paper burning opening usually faces south. Such openings are rather small in small-sized Xizi Pagodas. The paper burning openings of Xizi Pagodas in Shutang Village, Shaoyang County are 0.36 m high and 0.21 m wide (Figure 6B1). In comparison, such openings in large-sized Xizi Pagodas might be big enough to let a person through. For example, the opening of the Xizi Pagoda in Chating Town, Wangcheng District of Changsha is 2.09 m high and 0.75 m wide (Figure 6B2). The main purpose of the smoke expelling opening is ventilation and heat dissipation, and its orientation depends on local wind direction. Such openings have various shapes and styles. The opening of the Xizi Pagoda in Daxu Town, Yongzhou is flower-shaped (Figure 6B3), while that of the Xizi Pagoda in Yijiatian Village, Shaoyang is shaped as a coin (Figure 6B4).

At the top of the Xizi Pagoda is the vertical shaft, which ‘serves as the pagoda top and prevents rain from leaking’ [28]. It consists of the pedestal, body, and top. Most of the vertical shaft pedestals of Xizi Pagodas in Hunan are similar to a washbasin placed upside down; the body is usually shaped as a pen, a vase, or multiple rings; and the top is generally in the shape of a pen, an orb, a water drop, or an animal. The top of the Xizi Pagoda in Shanmuqiao Town, Wangcheng District, Changsha is in the shape of a pen tip (Figure 7A2), while that of the Xizi Pagoda in Xinzhong Village is shaped as a water drop (Figure 7A3).

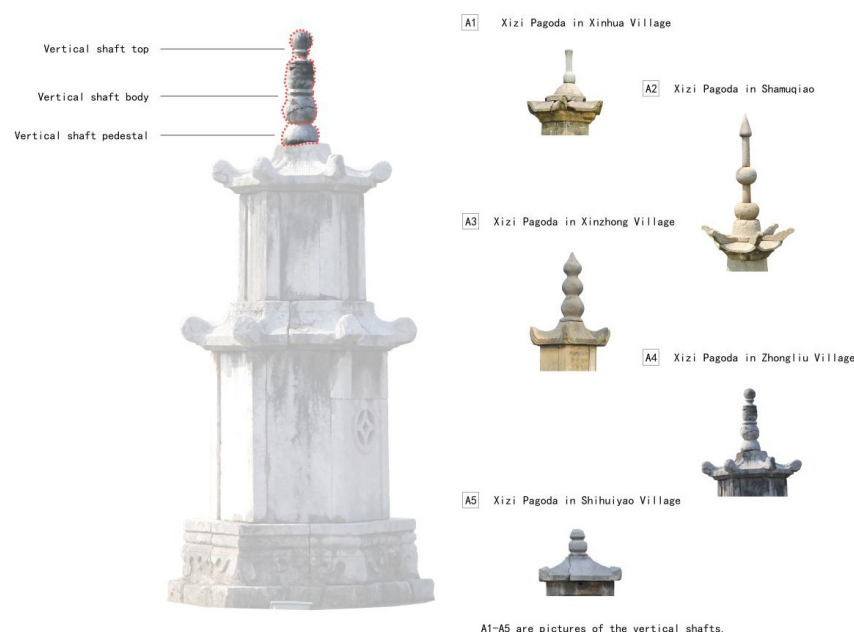


Figure 7. Vertical shaft of the Xizi Pagoda (image source: made by the author).

4.1.2. Artistic Value of the Xizi Pagoda

As a cultural structure with cultural and educational connotations, the Xizi Pagoda shows high artistic value in shape, material, and decoration. Being a perfect mix of strength and softness, it has a multi-layered beautiful shape. Viewed from a distance, the height, side length, and eaves of each floor shrink inward. The overall structure is pyramid-shaped, with a wide bottom and a narrow top. Take the Xizi Pagoda in Chating Town, Changsha County as an example. The height of each floor decreases from bottom to top, which is 2.89 m, 2.45 m, 2.12 m, 1.89 m, and 1.22 m, respectively, creating a sense of rhythm. The contour of the main body features clean straight lines, while the plane and components are highlighted by smooth curves. For example, in the Xizi Pagoda in Zhiji Village, Changsha County, the main body above the second floor is connected to the eave in a corbel structure, and the cornice shaped as a cirrus cloud curls up slightly. The hexagonal plane shape, which has the appearance of a circle, and the semi-circular opening form a contrast to the straight lines of the pagoda, and strike a perfect balance between strength and softness.

The artistic value of the Xizi Pagoda is also shown in its simplistic, natural, and solid material. Heidegger believes that both the truth and emotions can be preserved and manifested in the material [29]. Chinese people's preference for stones epitomizes their philosophy and attitude towards life, which shows that the aesthetic object and subject can impact each other and are interconvertible. Natural stones are commonly used material for Xizi Pagodas, such as granite and shale. Hard as they are, stones are resistant to fire, water, and corrosion, carrying connotations of primitive simplicity and giving people a reliable and calm impression. Uneven, rough, and distinct, stones create an image featuring peace of mind and an unbiased attitude. In addition to the artistic value of the material itself, the decorative carving on such stones adds a unique sense of beauty.

Wittgenstein believes that image is the expression of human language, and it is the linguistic medium for ideas of humans as well as for social and cultural memories [30]. The auspicious ornaments, immortals' image, and educational words on the Xizi Pagoda reflect a lyrical kind of beauty in decoration, which shows itself in three ways.

The first way is by expressing meaning with symbolic images and metaphors. The ornaments on the pagoda are inspired by natural things with auspicious meanings. By means of creating images, homophonic rhetoric, and metaphors, people express their wishes for happiness and blessing. Both the Xizi Pagoda in Yijiatian Village, Chengbu Miao Autonomous County, Shaoyang, and the one in Xinhua Village, Changsha County use dec-

orative patterns such as scroll, diamond, and fret, which are end-to-end regular patterns, referring to a thriving culture (Figure 8A1,A2). Sometimes, homophones are applied. The two lions carved on the Xizi Pagoda in Shali Village, Guiyang County, Chenzhou and the one in Qingshan Village, Jiahe County (Figure 8A4) are examples. Lion in Chinese, or shi, is a homophone to ‘thing’, so two lions can mean ‘good things should be in pairs’ or ‘everything comes off satisfactorily’. Additionally, there are long ribbons on the lions, which means that ‘good things never end’.

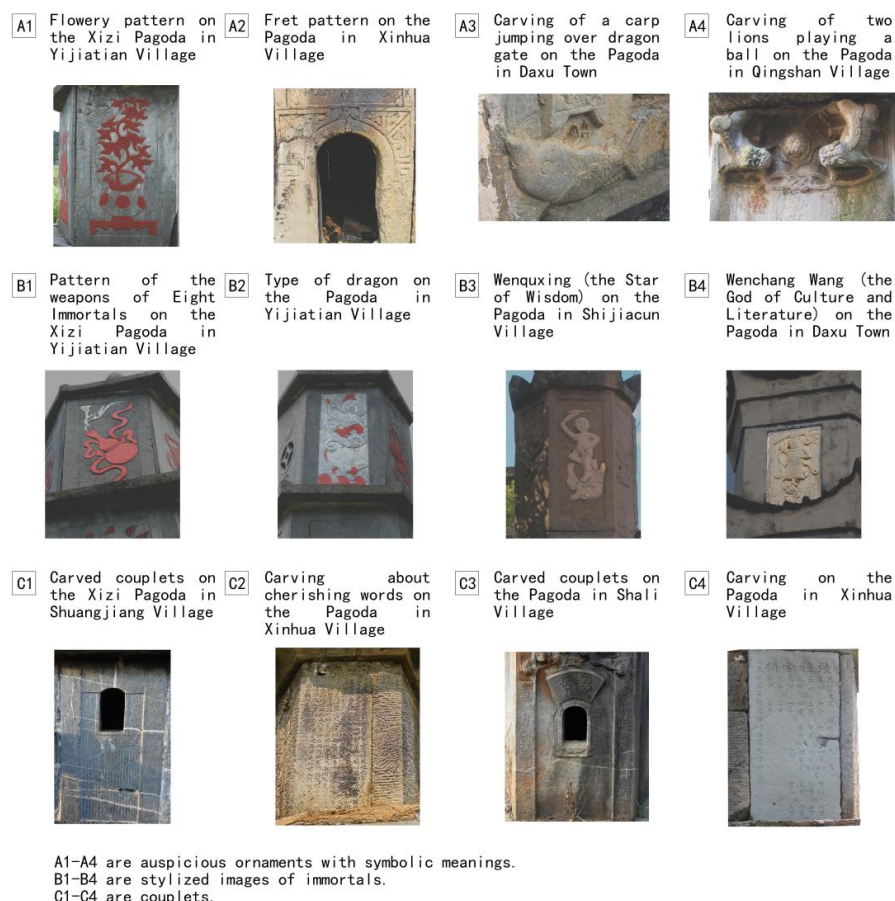


Figure 8. Examples of decoration on the Xizi Pagoda (image source: made by the author).

The second way is by depicting immortals’ images in flexible ways. The images in the decoration of Xizi Pagodas need to be simplified, leading to a unique artistic style (Figure 8B1–B4). On the wall of the third floor of the Xizi Pagoda in Yijiatian Village, weapons of the Eight Immortals are engraved, such as the gourd of Li Tieguai and the fan of Zhong Lique. It is too complicated to depict the Eight Immortals themselves, so their weapons are often used instead (Figure 8B1).

Image variations are also widely used in folk sculptures to enrich the content. The ancient Chinese believed that the dragon was a symbol of the emperor and should not be used at will by mundane people. Therefore, the dragon carved on the Xizi Pagoda in Yijiatian Village is a curved fret one with a regular dragon head, which is called Guazilong, or winding dragon (Figure 8B2). Dominated by feudalism for a long time, vast rural areas in China were in an agricultural society, where ‘passing on the family heritage by farming and reading’ became people’s lofty ideal and lifelong pursuit. Moreover, the Xizi Pagoda is a type of cultural and educational structure for literati cultivation, so the images of culture-related immortals, such as Wenchang Wang (the god of culture and literature) and Wenqixing (the Star of Wisdom) are often seen in the carvings. These figures speak to

people's aspiration for success in the imperial examination and for a thriving local culture (Figure 8B3,B4).

The third way is by writing inspiring couplets. The couplets carved on Xizi Pagodas are mainly themed around cherishing words and paper, cultivating culture, and doing good deeds (Figure 8C1–C4). As written in the couplets on the Xizi Pagoda in Shuangjiang Village, Guiyang County, Chenzhou (Figure 8C1), 'paper is burned in the hexagonal golden stove, while stars are within reach on the five-story pagoda'. This is supposed to teach future generations to cherish paper and respect knowledge. On the wall of the second floor of the pagoda in Xinhua Village, there are inscriptions about how people practiced the ceremony, how the pagoda functions, and how important it is to cherish writing paper. Although some parts are unrecognizable, the inscriptions basically mean that 'hence the stove was built for incineration . . . From now on, used writing paper will turn to ashes, as precious as . . . , and the thoughts of our forefathers will rise to the clouds instead of falling into the mud and being trampled on. Hopefully we can understand the difficulties they've encountered and show our respect for what they've left us' (Figure 8C2).

On the Xizi Pagoda in Shali Village, there is a couplet 'as the writing paper is burned in the pagoda, the smoke billows like the fragrance of ink' (Figure 8C3), which also conveys people's prayer for peace and prosperity. Most of the funds for building Xizi Pagodas were raised by certain groups with the same surname or in the same family or village. The names of the contributors were engraved on the pagodas of Xinzhong Village, Xinhua Village, and Zhiji Village. Their contribution to the pagoda will be everlasting in the form of stone carving (Figure 8C4).

4.2. Analysis of Stress and Structural Stability of the Xizi Pagoda

Many existing Xizi Pagodas in Hunan were built hundreds of years ago, which speaks to the durability of their load-bearing structure. This shows the mature architectural system of ancient Chinese craftsmen, as well as the science-based structure and the beauty of the pagodas.

4.2.1. Stress Structure of the Xizi Pagoda

Based on the field investigation of Xizi Pagodas in Hunan, the shape featuring a wide bottom and a narrow top can lower the center of gravity, enhance stability, and improve the overturning resistance to transverse loads. To meet the needs for paper burning and smoke expelling, a hollow main body is adopted, and the self-weight and wind load of the pagoda are mainly borne by the wall. Sometimes, beams are installed on each floor to improve the performance under stress. Most Xizi Pagodas in Hunan are small-sized and simple in structure. Compacted soil is used as the base, while the foundation base is built with masonry. The building material of the Xizi Pagoda is mostly natural stones, which are made into standard blocks or slabs, connected by lime mortar, and finally built into the Xizi Pagoda by stacking or splicing [31] (Figure 9).



Figure 9. Construction steps of the Xizi Pagoda and components of the solid foundation bed (image source: made by the author).

Xizi Pagodas fall into three categories according to different methods of construction: block stacking, slate splicing, and stacking plus splicing (Figure 10). The first one is classical masonry. Natural stone is processed into standard blocks, piled in a staggered way, and connected with lime mortar. It is easy to build and the stress is evenly distributed. The second is widely seen in small-sized Xizi Pagodas, whose main body is composed of large slate splicing. To be specific, large pieces of slate are connected with stone columns (or corner stones), forming a slab-column system. The third one is an integration of the previous two, where the lower part of the Xizi Pagoda is stacked and the upper part spliced.

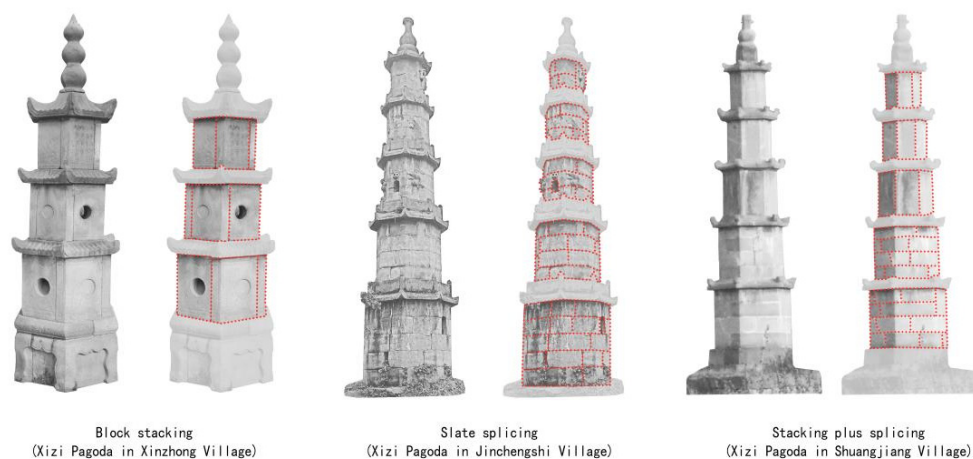


Figure 10. Three common construction methods of the Xizi Pagoda (image source: made by the author).

4.2.2. Stress Characteristics of Different Structures of the Xizi Pagoda Introduction of the Model

This study builds a model using data from typical structures of Xizi Pagodas in Hunan. With the help of the finite element software DIANA (10.5), a five-floor model was established based on the pagoda structure [32]. It has a height of 10.562 m and an inclination angle of 86.2° . According to different forms of the plane of Xizi Pagodas, analyses on regular quadrangle, regular hexagon, and regular octagon models were conducted, respectively. In light of the Code for Design of Masonry Structures [33], material parameters are assigned for the Xizi Pagoda in the stacking plus slicing structure: the code number of raw stone is MU100, the mortar is M2.5, the elasticity modulus of masonry is $E = 5650$ MPa, Poisson's ratio is $\nu = 0.15$, and the density is 1900 kg/m^3 . The assigned value of compressive strength and tensile strength of such a structure is 5 MPa and 0.7 MPa (stress), respectively. The calculation models for different types of Xizi Pagodas are shown in Figure 11.

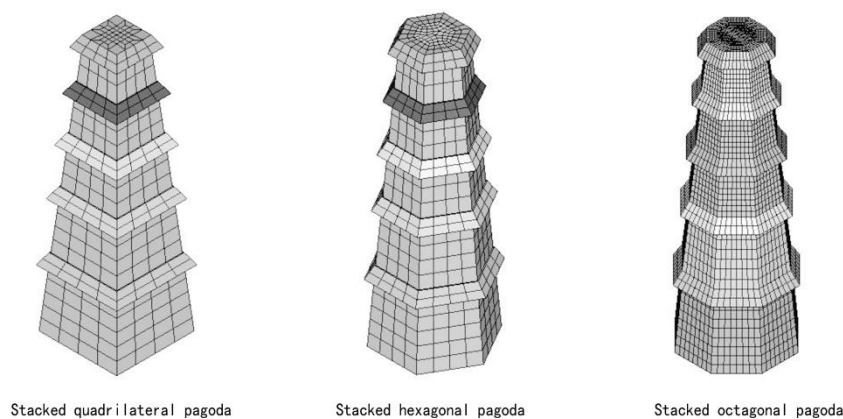


Figure 11. Calculation models for different structures of Xizi Pagodas (image source: made by the author).

Given the fact that Hunan is filled with rolling country hills, the geographical condition is good. Therefore, only the self-weight of the Xizi Pagoda and wind load are taken into consideration in finite element analysis. The value of the latter is assigned according to the Load Code for the Design of Building Structures [34], and the wind load is set as 0.35 KPa for high pagodas.

Structural Deformation Analysis of the Xizi Pagoda

The vertical deformation results of different types of Xizi Pagodas are shown in Figure 12, in which the maximum settlement of quadrilateral, hexagonal, and octagonal Xizi Pagodas is 2.96 cm, 3.15 cm, and 3.68 cm, respectively. While the volume remains the same, the more sides there are in the polygon, the deeper the settlement is. The settlement of quadrilateral pagodas is more even, while that of the hexagonal and octagonal ones is uneven. The relative settlement difference at the top of the pagoda is about 2–3 mm, and the inclination angle of uneven settlement is about $0.03\text{--}0.04^\circ$, so the overall deformation of the building is not severe.

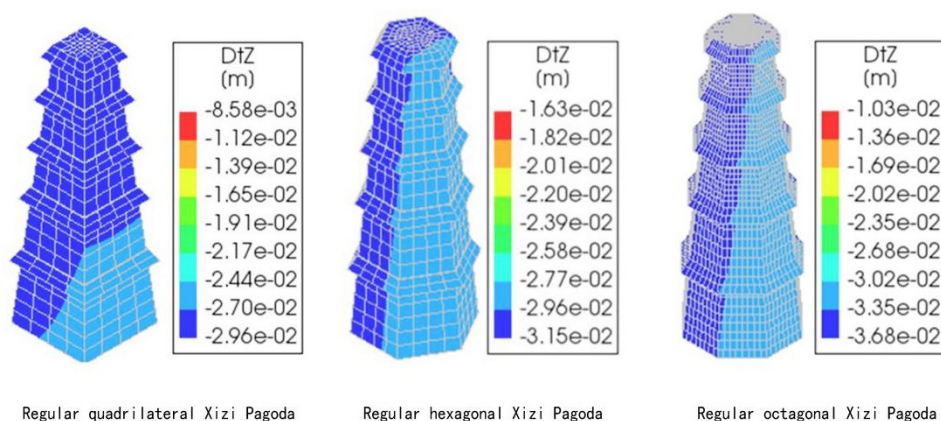


Figure 12. Results of vertical deformation of the Xizi Pagoda (image source: made by the author).

Figure 13 is the nephogram of the horizontal deformation of the Xizi Pagoda. As shown in Figure 13, the deformation of the three types are similar, with deformation inclined to one side. The top of the pagoda is the most deformed and the bottom is the least deformed. Among the three, the quadrilateral pagoda has the smallest extent of horizontal deformation, while the octagonal one has the largest. The horizontal deformation of the top of quadrilateral, hexagonal, and octagonal is 5.63 mm, 8.11 mm, and 13.6 mm, respectively. Results show that with the increase in the number of sides, the pagoda is more deformed horizontally as the number of polygon sides increases, since the windward area of the pagoda will be larger.

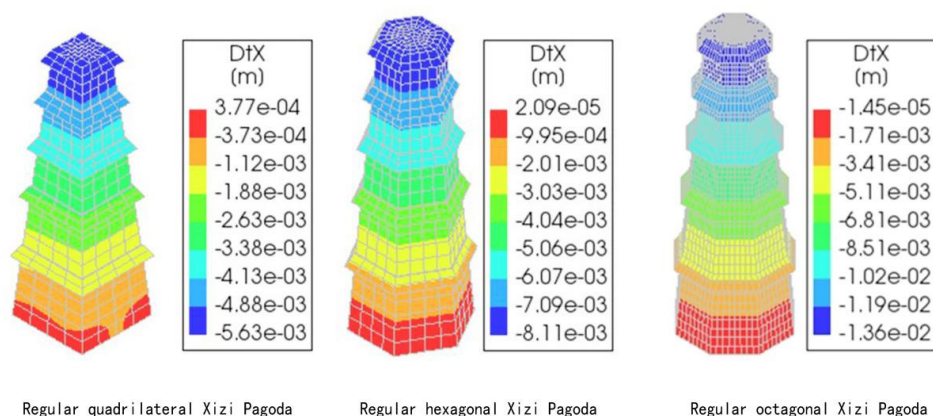


Figure 13. Results of horizontal deformation of the Xizi Pagoda (image source: made by the author).

Based on the above analysis, in the case of the natural load, the horizontal inclination and uneven settlement of the structures of Xizi Pagodas are rather small, and the whole structure is relatively stable. While the height remains the same, there are differences in the deformation of pagoda bodies in different plane forms. The larger the number of polygonal sides is, the greater the overall deformation will be.

Internal Force Analysis of the Xizi Pagoda

By analyzing the internal force distribution of the Xizi Pagoda structure, the nephograms of the maximum and minimum principal stresses of different types of Xizi Pagodas are obtained, as shown in Figures 14 and 15.

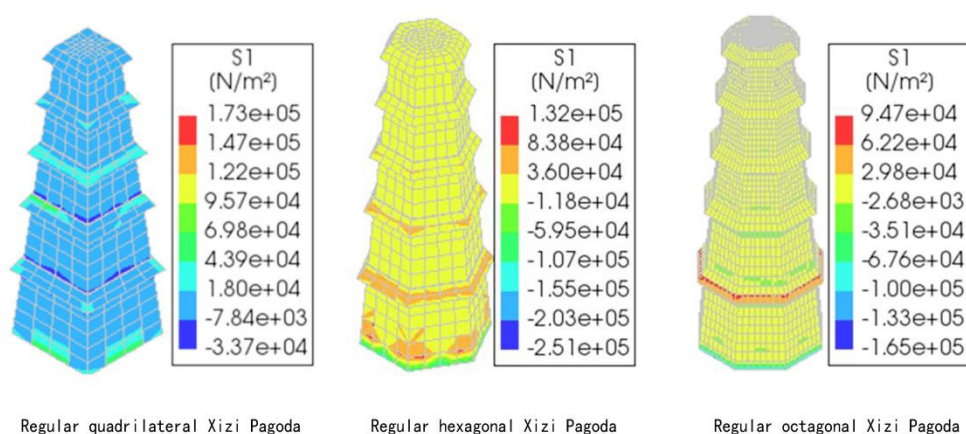


Figure 14. Nephogram of the maximum principal stress of the Xizi Pagoda (image source: made by the author).

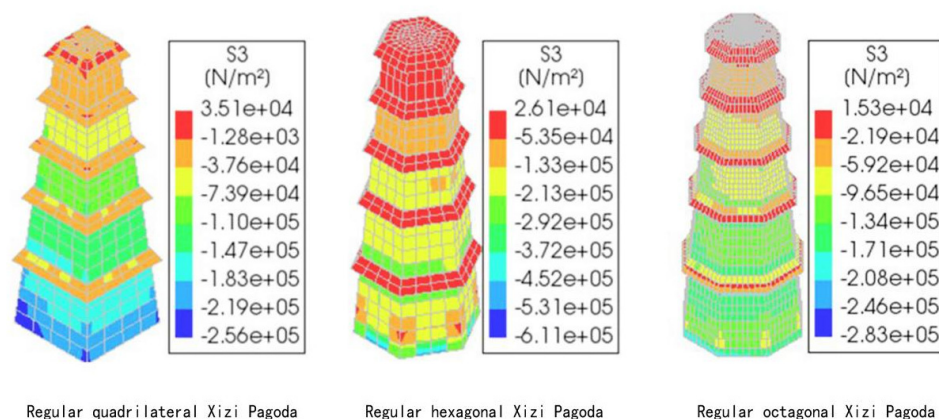


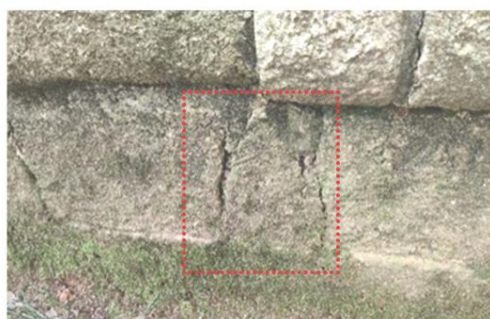
Figure 15. Nephogram of the minimum principal stress of the Xizi Pagoda (image source: made by the author).

Analysis of the maximum principal stress of different types of pagoda structures (Figure 14) shows a pattern in the distribution of such stress, which should be below zero in most parts of the main body, indicating that the compressive stress is borne by the main body of the pagoda. However, at the bottom and eave, the maximum principal stress is above zero, and there is a tensile stress concentration at the eave of low-rise pagodas. It shows that these parts are in tension, but the overall tensile stress is low, not exceeding 0.173 MPa , which is within the designated range of the tensile strength of the Xizi Pagoda structure.

Analysis of the minimum principal stress of different types of pagoda structures (Figure 15) reveals a pattern in the distribution of such stress, which is shown as compressive stress. The pressure value of the main body gradually increases from the top to the bottom,

and the maximum compressive stress is borne by the foundation bed of the pagoda. The minimum principal stresses of quadrilateral, hexagonal, and octagonal Xizi Pagodas are 0.256 MPa, 0.611 MPa, and 0.283 MPa, respectively, which are all well within the designated range of the tensile strength of the Xizi Pagoda structure. At the eaves of the pagoda, the minimum principal stress is still above zero, indicating that these parts of the pagoda are in full-section tension.

The internal force analysis shows that both the maximum tensile stress and compressive stress of the main body of the Xizi Pagoda are within the designated range, which enables the structure to withstand the stress. There is a certain level of tensile stress concentration at the bottom and eave of the pagoda. Limited by ancient masonry techniques, the tensile performance of such a masonry structure is poor, so cracking may occur in these parts [35]. Field investigation found cracks at the foundation bed pedestal and eave of the pagoda, as shown in (Figure 16). Therefore, it is suggested that priority be given to protecting such weak parts of the damaged structure of Xizi Pagodas in the protection and restoration of cultural relics [36].



Cracks at the foundation bed



Cracks at the eave of the first floor

Figure 16. On-site photos of cracks (image source: taken by the author).

4.2.3. Structural Protection and Style Restoration of the Xizi Pagoda

According to previous structural stress analysis, the overall internal force and structural deformation of the Xizi Pagoda are relatively small under regular load, and the structure is safe and stable. However, with years of weathering, it fails to resist some special loads in nature. Long-term rainfall and water level variations lead to poor cohesion in masonry structures, softening of the foundation and the correspondingly damaged bearing capacity, uneven settlement and inclination of the pagoda body, and even collapse [37].

Therefore, to prevent disasters such as tilting, damage, and even collapse of the structure, it is crucial to improve the foundation and enhance the structural strength of the pagoda. For example, the Xizi Pagoda in Chating Town, Wangcheng District, Changsha, which was built during Emperor Guangxu's reign of the Qing Dynasty, is a hexagonal pagoda with five floors. Its wall is a double-layered hollow structure, whose interstice is filled with soil. A nettle tree grew on the top of the pagoda, with a height of 7 m and a trunk diameter of 0.8 m, which is rare across the world. The roots grow thicker by absorbing the nutrition from the soil in the wall, and keep going downward. As a result, the pagoda body was squeezed and cracked, putting itself and the tree in danger of collapse.

In 2006, Liu Su and fellow researchers of Hunan University formulated a detailed protection plan (Figure 17). On the one hand, they reinforced the main structure, the roots of ancient trees growing in the pagoda wall were pruned, and the granite near the roots was moderately polished, so that certain space for growth was reserved, and problems such as cracking of the pagoda body caused by wall squeezing due to the growth of the roots were avoided. There is a steel structure frame in the pagoda, which strengthens the overall rigidity of the structure and prevents the pagoda from tilting. On the other hand, in terms of materials, the filling soil, which could strengthen the pagoda wall without hurting

the roots, was used, and lime was added for sterilization and insect prevention. This plan aims to strengthen and protect the tree and the pagoda under the prerequisite of preserving the original appearance of the two to the full extent.

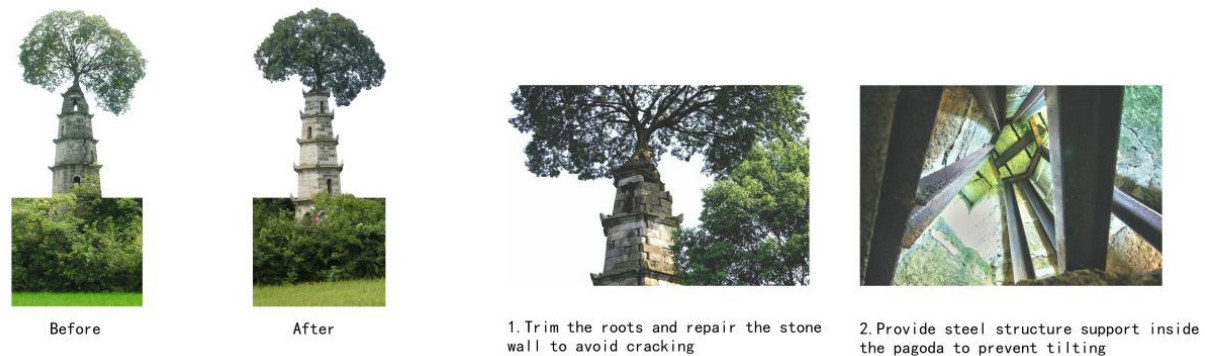


Figure 17. Protection measures for the Xizi Pagoda in Chating (image source: online).

In restoring the decoration and style of the Xizi Pagoda, repairers should address the inconsistency between new building materials and techniques and the original, as well as the passing on of culture, arts, and related beliefs. For example, the paper entrance of the Xizi Pagoda in Xinhua Village (Figure 18) was repaired with cement mortar, which is not in harmony with the dark grey color and roughness of the granite. The original carving was the fret chiseled by a craftsman, a symbol of good luck. The lines are clear and strong, and the overall pattern is simple yet grand. However, the repaired version is merely a similar sketch on the surface of the cement mortar created when it was still wet. Moreover, the cement mortar used for repair is not only inconsistent with the original color of the pagoda, but is also not resilient enough, which might lead to subsequent damage. Due to the failure to use the right materials and techniques, the restored pagoda lost all its grandness and solemnity accumulated from the past centuries.

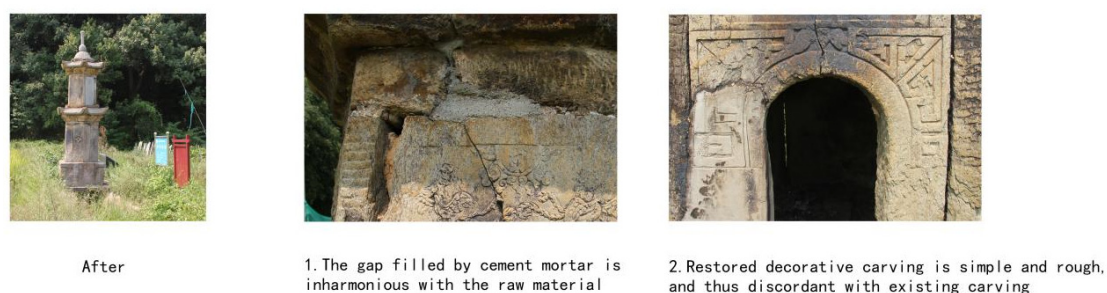


Figure 18. Problems in the protection of the Xizi Pagoda in Xinhua Village (image source: taken by the author).

In the repair of the Xizi Pagoda in Hebian Village, Longhui County (Figure 19), the eaves, together with twigs and weeds on the pagoda body, were cleaned, and the facade was waterproofed, thus avoiding the risk of soaking the foundation bed, leaking, and grass growing on the pagoda body. Meanwhile, the repairers upheld the principle of ‘restoring the old as before’ with minimum intervention, and repaired the wall, murals, clay animals, and statues fallen off the pagoda, so as to preserve the historical and cultural features to the greatest extent. Therefore, restoration of the Xizi Pagoda should be based on knowledge of its history and culture, insights into its artistic value, and mastery of techniques. Moreover, against the backdrop of rural revitalization, such structures, where people used to burn writing paper could be transformed into landmark public buildings in rural areas after restoration and re-utilization. This helps to spread the culture of cherishing words, pass on the passion for knowledge, and enhance cultural identity.



Figure 19. Protection measures for the Xizi Pagoda in Longhui County (image source: online).

The Xizi Pagoda is a structure for burning writing paper, praying for happiness, and educating the public. Field investigation shows that many Xizi Pagodas are near schools or by the river, where it is easy to find writing paper and send paper ashes to the sea; some are located in village entrances or ancestral halls as landmark buildings, which epitomizes people's aspiration for a thriving local culture, cultivation of talent, and bringing glory on their ancestors. However, in the protection and utilization of the Xizi Pagoda, repairers should avoid certain traps, such as protection limited to the pagoda, isolated restoration, and disharmony between the modern context and traditional buildings. For example, the restoration of the Xizi Pagoda in Shanmuqiao (Figure 20) only focused on the structure and ornamentation of the pagoda, while overlooking the fact that it is surrounded by a construction site of a modern business area, and failed to protect the pagoda and its external environment as a whole.



Figure 20. Problems in the protection of the Xizi Pagoda in Shanmuqiao (image source: taken by the author).

Built in the ninth year of Emperor Daoguang's reign (1829), the Xizi Pagoda in Juanshi Village, Changsha County, Changsha was buried in a fruit forest, with its Sumeru pedestal almost covered in mud and the opening for paper burning piled up with dirt. Engraved on the pagoda are the words 'Built by the Huang Family', but that ancestral hall is nowhere to be found. With targeted environmental restoration, the overall structure of this pagoda was strengthened, and tailored landscaping was carried out in the surroundings (Figure 21). First, the original site of the pagoda at the village entrance was preserved as a landmark. Second, around 6 m² of granite ground was paved centered on the pagoda, surrounded by the granite fence. The pagoda was connected to the township road to the west, and featured by a pond full of lotus in the east. Information boards were set up around the pagoda to present this building to visitors and promote the Xizi Pagoda culture.



Figure 21. Protection measures for the Xizi Pagoda in Juanshi Village (image source: taken by the author).

5. Discussion

In terms of protecting the tangible heritage of the Xizi Pagoda, researchers' understanding of the construction rules of traditional Chinese buildings is helpful for the protection and restoration of such structures. According to China's traditional building rules, the floors of a pagoda must be odd-numbered (known as yang, or positive number), while the polygon sides of the plane must be even-numbered (known as yin, or negative number) [38]. During field visits and investigations, it is found that the plane and facade of the Xizi Pagoda in Hunan conforms to this rule perfectly, as the polygon sides of the plane are even-numbered, being regular quadrilateral, hexagonal, or octagonal, accounting for 19%, 68.7%, and 12.3%, respectively. The floors of the facades are mainly odd-numbered, mostly one, three, or five, accounting for 18.75%, 31.25%, and 25%, respectively. This criterion is an important theoretical basis and practical standard for Xizi Pagoda restoration.

The brilliant combination of components and science-based structural stress bring stability and firmness to the pagoda. The Xizi Pagoda in Hunan adopts the masonry structure of splicing plus stacking, and ring beams are used in the joints. This structure ensures even transfer of pressure of the pagoda body from top to bottom, or to the solid foundation bed, so that the whole structure of the pagoda achieves a balance in stress (Figure 22). Stone arches at the openings of the Xizi Pagoda transfer the pressure to the pedestal as directed by the tangent, which prevents the portal from collapsing while maintaining its stability. Moreover, unlike openings with straight lines, the arch shape is softer, smoother, more flexible, and shows greater strength.

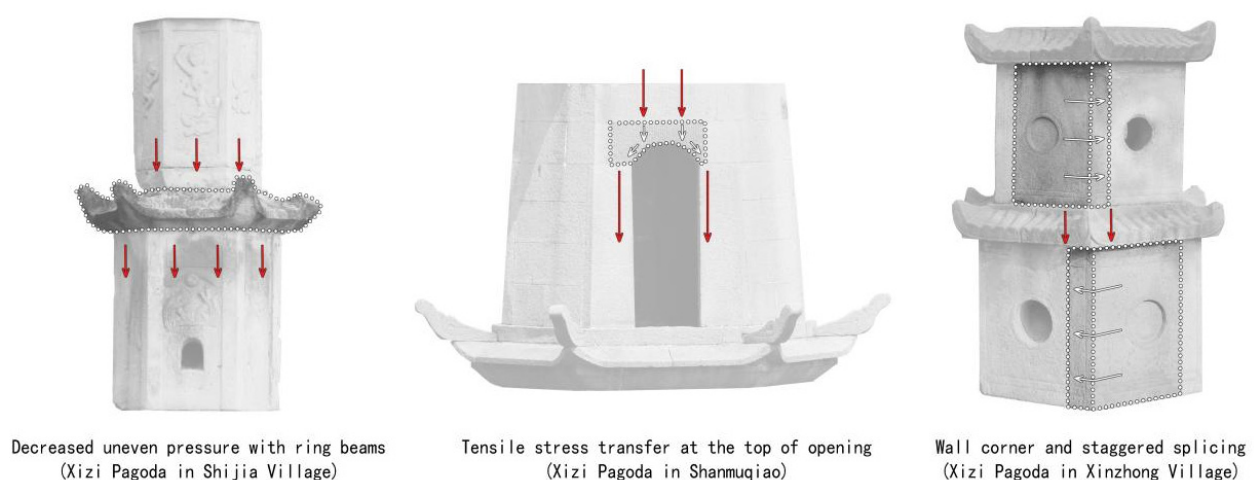


Figure 22. Components and techniques of the Xizi Pagoda (image source: made by the author).

As a long-lasting building with cultural and educational connotations, the Xizi Pagoda epitomizes not only the science of structural pressure, but also the artistic value (Figure 22). Based on the structural deformation analysis, although hexagonal and octagonal Xizi Pagodas in Hunan are not as stable as quadrilateral ones, their scores in the structural deforma-

tion index are below the critical value of maximum tensile stress, and are still in a stable state. The reason is that each facade of the pagoda body is spliced in a staggered manner, and corner stones are set up at the corner, which ensures the stable connection of the facades (Figure 22). Therefore, in the protection of the Xizi Pagoda, reinforcement should be conducted in accordance with the original splicing and stacking. Repairers should consider the arch shape at the opening and use corner stones to reinforce and connect the damaged parts of the structure. The above-mentioned methods enable the protection of ancient buildings to go beyond physical repair and truly achieve restoration based on local conditions in terms of both techniques and structure.

Hunan used to be a land of wilderness in ancient times with its complex terrain and tough geological conditions. As a result, people in Hunan became capable of bearing hardships, working hard, and making breakthroughs. This explains the brilliant components of the Xizi Pagoda, such as corner stones, ring beams, and arc-shaped openings. The structure is an epitome of the perseverance and humanistic pragmatism of the forefathers in Hunan, leaving the world with a bunch of remarkable artistic and cultural heritage represented by the Xizi Pagoda.

In the protection of the Xizi Pagoda, besides mastering the code of architecture, repairers should also understand the cultural connotations. Field investigation and finite element simulation analysis show that the overall structure of the pagoda is pyramid-shaped, with a wide bottom and a narrow top. In addition to providing structural stability, such a structure has a multi-layered and progressive beauty in it, and plays a role in encouraging future generations to study hard and adopt a positive attitude. Through field investigation and literature review, it is found that the structure also contains the Taoist philosophy of 'combining virtuality with reality'. The solid base, pagoda wall, and heavy eaves are the 'real' parts of the structure, presenting a sense of reliability and solemnity. The hollow inside, together with openings for paper burning and smoke expelling gives people peace of mind, which is the 'virtual' part of the pagoda. The combination of virtuality and reality of the pagoda inspires people to be down-to-earth, use critical thinking, and understand the subject thoroughly in their learning. The solid pagoda wall and the hollow inside and openings are a perfect match, fulfilling pragmatic functions and artistic value at the same time.

So far, Erxiang Village in Chenzhou City, Hunan Province still observes the custom of cherishing writing paper. During the design of village transformation, the team led by Professor Xie Xubin from Central South University planned to restore a full stone pagoda structure with a hollow inside, which would be integrated with the local temple and become part of the landscape. The materials would be granite, a common local resource, and the design combines the traditional form of Xizi Pagoda with modern artistic expression, which will enable the preservation and re-utilization of the architectural heritage of Xizi Pagoda in modern rural China. The Xizi Pagoda in Erxiang Village will continue to fulfill the function of burning paper as it used to do in ancient times; meanwhile, it will also serve as a landmark at the entrance of the village.

After investigation and analysis of the Xizi Pagodas in the surrounding villages, the team decided on a three-story structure for the main building. As for the main body of the pagoda, the image of 'flickering flames' in the works of Gu Hua, a famous Chinese novelist, was introduced in the stove to burn writing paper, and transformation will be conducted based on materials at hand. In the structural design of the second floor, the original ventilation opening is shaped as the Chinese character Gu (or '古'), while flame-shaped lamps are placed in the stove for lighting. On the third floor, glass is used, which appears as a revolving scenic lantern. This successfully presents the forest fire scene described in the book *Pa Man Qing Teng De Mu Wu* (which literally means 'Wooden House Covered with Ivy'), and highlights the theme of ecological protection in Gu Hua's local literature (Figures 23 and 24). The location at the entrance of the village shows that the village is home to renowned literati, adding a scholarly touch to the place and fulfilling the purpose of talent cultivation.

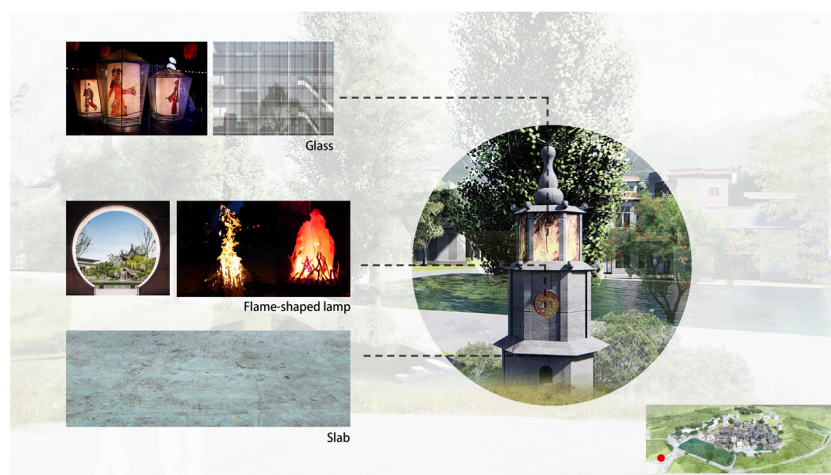


Figure 23. Material and desired result of the stove in the Xizi Pagoda (image source: made by the author).

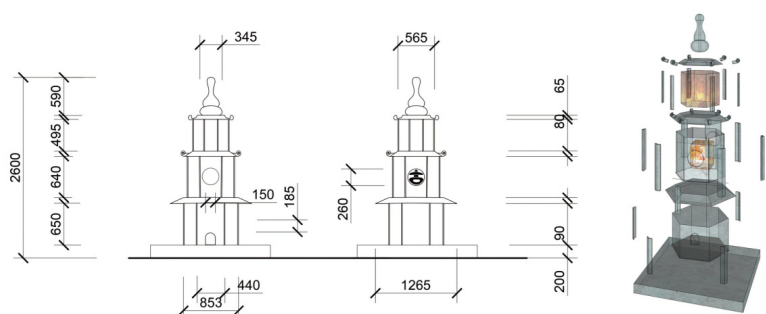


Figure 24. Size and structure of the stove in the Xizi Pagoda (image source: made by the author).

Today, the emerging new media has a dominating position, as they are quick to react, easy to use, highly customized, and interesting. They are gradually replacing traditional paper media and letting the public develop the habit of ‘fragmented reading’. ‘Survey shows that the exposure to digital reading in 2019 was 79.3%, up by 3.1 percentage points from 76.2% in 2018. In 2019, each adult read 4.65 paper books on average, slightly lower than 4.67 in 2018’ [39]. The increasingly digital and entertaining way of reading exerted great impacts on the writing environment, people’s mentality, and culture.

In the new media era, the threshold for writing and expression is being lowered, the quality of available information is declining, and the knowledge people acquire is not as profound as before. The in-depth, systematic, and rigorous way of thinking cultivated by paper reading is being replaced by a superficial, fragmented, and fallible one. The seriousness of characters and the sanctity of writing paper are gradually disappearing amid social transformation and informatization, as is the special bond between people and words. China’s traditional Xizi culture, rites, and pagodas set an example in dealing with used writing paper, and build a consensus over cherishing literature and honoring ceremonies. Protecting the Xizi Pagoda and passing on the culture helps people in deepening their understanding of traditional culture, such as cherishing writing paper, regaining their respect for words, and addressing social issues, such as fragmented reading and the use of words for entertainment.

The architectural landscape of the Xizi Pagoda emphasizes the combination of externalization education of objective expression and introspection of psychological consciousness, which was the material expression of the social thoughts of ‘emphasizing education’, ‘enjoying learning’, and ‘respecting ceremony’ at that time. At present, the protection of the architectural heritage Xizi Pagoda is not only for material restoration, but also needs

to encourage more people to participate in the ceremony of cherishing words, visit Xizi Pagodas, study the inscriptions on the pagoda wall, and appreciate the artistic decoration. This can help inspire the public's mind and encourage them to reflect upon themselves, so as to achieve the purpose of continuing the belief in cherishing words, inheriting the spirit of literati and strengthening cultural confidence.

In light of empirical research, stress calculation, and aesthetic analysis, a study on protecting the architectural landscape of the Xizi Pagoda can be conducted from the following three aspects: spatial structure, artistic value, and cultural inheritance. The first aspect is spatial structure. The reinforcement of the main structure of the Xizi Pagoda should focus on optimizing the foundation form and strengthening the structural strength, which can be realized by stone replacement, CFRP sticking, and injection. In terms of materials, the ideal choice is composite materials, which can strengthen the main body and are resistant to damages caused by insects and mosquitoes. The materials should be durable and stable, and their adhesion to rock cracks should be close to or slightly greater than the mechanical strength of the structure itself. Moreover, they should be easily injected and able to solidify at room temperature, which will facilitate the construction process. Attention should also be paid to the color and toxicity. In terms of repair techniques, traditional craftsmanship should be adopted to avoid disharmony.

The second aspect is artistic value. Repairers should balance the inheritance of decorative arts and their role in shaping belief and education in a unified, coordinated, and science-based way. For the repair of the Xizi Pagoda, it is vital to understand the history and culture, have aesthetic insights, and master relevant skills.

The third aspect is cultural inheritance. It is necessary to regain respect for words and address social issues, such as fragmented reading and use of words for entertainment. The government and competent authorities should encourage people to participate in the ceremony of cherishing writing paper, visit Xizi Pagodas, study the inscriptions on the walls, and appreciate the artistic decoration.

6. Conclusions

This study deepens people's understanding of the relationship between the Xizi Pagoda and the Xizi culture, and gives an overview on the current preservation of the pagoda and the weak links. Unlike existing research focusing on a certain aspect, this study comprehensively analyzes the spatial structure and artistic value of the pagoda for the first time, combining the disciplines of heritage, architecture, structural mechanics, and art. The aim is to explore methods for preservation and reuse of traditional buildings in China under the current context of architectural heritage protection.

According to the research questions and objectives proposed in the introduction, the conclusions of this study are as follows:

First, in terms of the spatial structure, the Xizi Pagoda has a hollow main body and falls into three categories based on the model of construction: block stacking, slate splicing, and stacking plus splicing. Their planes are in a symmetrical shape, dominated by hexagonal and followed by quadrilateral and octagonal. The facades of the Xizi Pagoda tend to be odd-numbered: mostly one, three, or five-story. In terms of components, the Xizi Pagoda mainly consists of three parts: foundation bed, main body, and vertical shaft. The foundation bed includes the abutment and the pedestal. The main body includes the eave, cornice, ladder, opening, and ceiling. The vertical shaft includes the pedestal, body, and top. The Xizi Pagoda shows high artistic value in shape, material, and decoration. As a perfect mix of strength and softness, the pagoda has a multi-layered beautiful shape; it features simplistic, natural, and solid materials, and it also reflects a lyrical kind of beauty in decoration.

Second, this study shows that the stability of the Xizi Pagoda is related to its plane shape and components. The shape featuring a wide bottom and a narrow top can lower the center of gravity, enhance stability, and improve the overturning resistance to transverse load. While the height remains the same, there are differences in the deformation

of pagoda bodies in different plane forms. The larger the number of polygonal sides is, the greater the overall deformation will be. In terms of methods of construction, block-stacked pagodas are classical masonry. Natural stone is processed into standard blocks, piled in a staggered way, and connected with lime mortar. It is easy to build and the stress is evenly distributed, which speaks to its science-based nature in terms of spatial structure and building techniques. In terms of cultural connotations and craftsmanship, the architectural landscape of the Xizi Pagoda emphasizes the combination of the externalization education of objective expression and introspection of psychological consciousness, which was the material expression of the social thoughts of ‘emphasizing education’, ‘enjoying learning’, and ‘respecting ceremony’ at that time. It also contains the Taoist philosophy of ‘combining virtuality with reality’, and speaks to the fact that people in Hunan are capable of bearing hardships, working hard, and making breakthroughs.

Third, the number of Xizi Pagodas plummeted, and many of the remaining ones are damaged and in urgent need of rescue. Studies on protecting the architectural landscape of the Xizi Pagoda can be conducted from the following three aspects: spatial structure, artistic value, and cultural inheritance. In terms of spatial structure, the reinforcement of the main structure of the Xizi Pagoda should focus on optimizing the foundation form and strengthening the structural strength, while the materials should be durable and stable. In terms of artistic value, protecting the Xizi Pagoda requires mastery of ancient building techniques and rules, and also an in-depth understanding of its cultural connotations. In terms of cultural heritage, the belief in cherishing words and respecting paper is fading away, and the sacredness of words is declining, while systematic and coherent reading is being ignored. It is of great significance to carry forward the national spirit and the Xizi culture. This will contribute to creating a scholarly social vibe, enabling traditional culture to prosper, and creating a new cultural landscape.

This study provides a scientific basis and feasible methods for the protection and utilization of the Xizi Pagoda and the inheritance of the Xizi culture. However, this study has room for improvement due to the limited amount of time and knowledge reserve. For example, the analysis and research on Xizi Pagodas in Hunan is not thorough and comprehensive enough, and more detailed and systematic research is needed on disaster relief (such as earthquake) and moisture protection. Meanwhile, the path to modern protection, development, and innovative design based on the architectural heritage Xizi Pagoda needs further improvement. It is the authors’ hope to provide science-based observations and practical reference for the protection and utilization of the architectural landscape of China’s Xizi Pagoda, and for the inheritance and innovation of China’s outstanding traditional culture.

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