Study on Typhoon Damage and Renovation of Cultural Relic Buildings in China --Taking Honglincuo as an Example

Wenjiang Zou[1], Shanshan Zhu[2] and Yiwei Men[3]

[1] Master, School of Architecture, Southwest Jiaotong University, P.R. China
(Sichuan,Chengdu,611756,China)
[2] PhD Candidate, School of Architecture, Southwest Jiaotong University, P.R. China
(Sichuan,Chengdu,611756,China)
[3] Master, School of Architecture, Southwest Jiaotong University, P.R. China
(Sichuan,Chengdu,611756,China)

Typhoon frequently hits China's southeast coast, causing damage to a large number of historic buildings. In the process of participating in China's 13th Five-Year National Key Research and Development Program "Study on Natural Disaster Risk Assessment and Emergency Disposal of Immovable Cultural Heritage" (2019YFC1520800), found that Fujian, located in the southeast coastal area, is affected by typhoon disasters, and the disasters characteristics and protection and restoration work of cultural relic buildings are representative in the region. Honglincuo, the provincial cultural relics protection unit in Fujian as the research project, based on literature and information, it analyzes damage characteristics and renovation process of the buildings after the disaster. Furthermore, three suggestions are put forward including improving the policy, regulation system and disaster prevention technology, establishing the disaster prevention and protection mechanism, and enhancing the protection management and public participation.

Keywords: *Typhoon disaster; Cultural relic buildings; Damage and renovation; Preventive conservation*

1. Research Background

Typhoon is one of the most serious and frequent natural disasters in the world [1)]. Typhoon occurs mainly in eight sea areas worldwide (Fig.1), including five sea areas in the western and eastern North Pacific Ocean, western North Atlantic Ocean, Bay of Bengal and Arabian Sea in the Northern Hemisphere, and three sea areas in the western South Pacific Ocean, western and eastern Southern Indian Ocean in the Southern Hemisphere. Globally, there are an average of 62 typhoons a year, among which the northwest Pacific Ocean tops the list (accounting for more than 36%) [2)]. China is located right in the northwest Pacific Ocean. Typhoon frequently hits China's southeast coastal region, and this region suffers from typhoons to varying degrees for about three-quarters of the year, especially during the typhoon-prone period from July to September. Fujian is one of the most vulnerable and severely affected provinces of typhoon disaster in the southeast coastal area [3)], therefore, the damage characteristics, protection and restoration of cultural relic buildings in Fujian have regional representativeness. This paper selects Honglincuo, the provincial cultural relics protection unit in Fujian as the research project (Fig. 2 and 3), based on literature and news reports, it sorts out the damage and renovation process of the buildings after the disaster, aiming to study the damage

and renovation methods of the cultural relic buildings in the region affected by typhoon, so as to provide some case experience for the global cultural relic buildings to cope with the typhoon disaster, and to give suggestions for the protection and renovation of cultural relic buildings based on the preventative conservation theory.

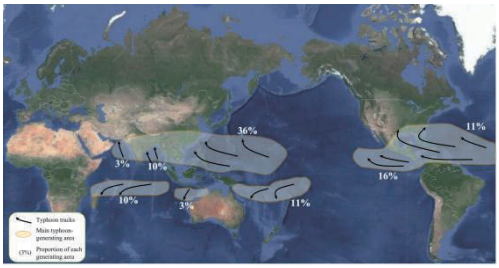


Fig.1 Distribution Map of Typhoon Disaster

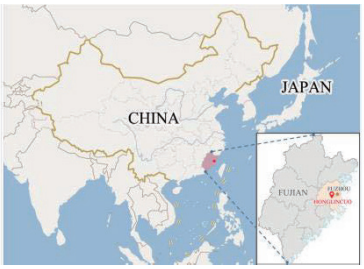


Fig.2 Location of Honglincuo

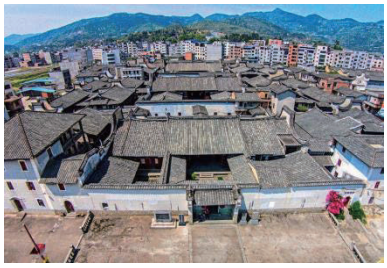


Fig.3 Reality Image of Honglincuo [4)]

2. Style and Features of Buildings in Honglincuo

Honglincuo is located in Xinhu Village, Bandong Town, Minqing County, Fuzhou City, Fujian Province. Founded in 1795, Honglincuo is the largest single-building ancient dwellings in China, and it has long been known as the "Folk Palace Museum" [5)]. In 2005, Honglincuo was listed as the Provincial Cultural Relics Protection Unit in Fujian. The whole dwellings have 35 halls, 30 patios, 36 fire walls, 4 wells and 666 houses [6)]. Honglincuo adopts a complete and symmetrical layout of three-entry courtyard. The first entry is the living room for greeting guests, the second entry is the living room for daily life, and the third entry is the place for religious sacrifice (Fig.4 and 5). The main body of the building is wooden structure, and the outer parapet is the rammed earth wall. The building typically has two or three floors. The bottom overhead is usually closed, with only a vent of 10*10cm. The first and second floors mainly consist of living room, kitchen, bedroom and toilet. The top floor is the attic, which used for storing farm tools and grain. It also has a small ventilation window for ventilation and heat insulation in summer[7)] (Fig.6).

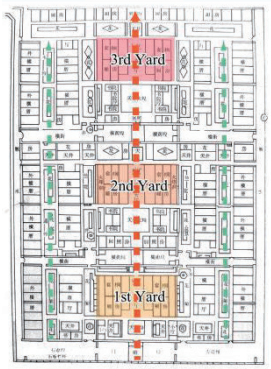


Fig.4 Floor Plan of Honglincuo

Fig. 5 Courtyard and Indoor Floor Plan of Honglincuo[8)]

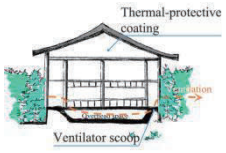


Fig.6 Diagrammatic Cross-section of Honglingcuo

3. Overview of Damage and Renovation Process of Honglincuo

(1) Overview of building damage of Honglincuo

At 13:45 on July 9, 2016, Typhoon "Nepartak" landed in the coastal area of Fujian, affecting 655,300 people and causing direct economic losses of 9.994 billion yuan[9)]. Honglincuo was devastated by "Nepartak" and heavy rainstorm, mountain torrents and debris flow brought by it(Fig.7a). The flood water level caused

by the typhoon was as high as 3.5 m, exceeding the flood control standard for the initial construction of the building. The lower stone foundation of most walls of Honglincuo is less than 1m, additionally, the external plaster layer flakes off seriously. After the floodwaters overflowed the foundation, the rammed earth walls, which had been immersed in water for hours, rapidly lost strength and then collapsed, bringing down the wooden structures inside. Therefore, long time immersion and erosion are the major reasons for damage of Honglincuo. According to the field investigation, door wall, two corridors and pavilions of the first entry of Honglincuo collapsed seriously (Fig.7b), and the main structural frame of the second and third entry slightly damaged. Two thirds of the longitudinal wall of the outer building in the south collapsed (Fig.7c), the observation tower in the north collapsed completely, covering an area of more than 2,000 square meters, and more than 110 houses toppled over. In addition, as a result of being soaked by the flood, there were local cracks and looseness in the three-story turret, which caused certain safety risks [10](Fig.7d).

(a) (b) (c) (d)

Fig. 7 The damage of Honglincuo[10)11)]

(2) Building renovation process of Honglincuo

a) The government authorities launched the implementation plan for restoration after disaster

On August 3, 2016, General Office of Fuzhou Municipal Government of Fujian Province officially issued the *Implementation Plan for Post-disaster Restoration and Reconstruction of Public Service Facilities including Culture, Education, Health and Sports in Fuzhou City*, which put forward a clear time for the post-disaster restoration work of Honglincuo [12] (Table 1). All departments and units quickly carried out protection and renovation work in accordance with the implementation plan.

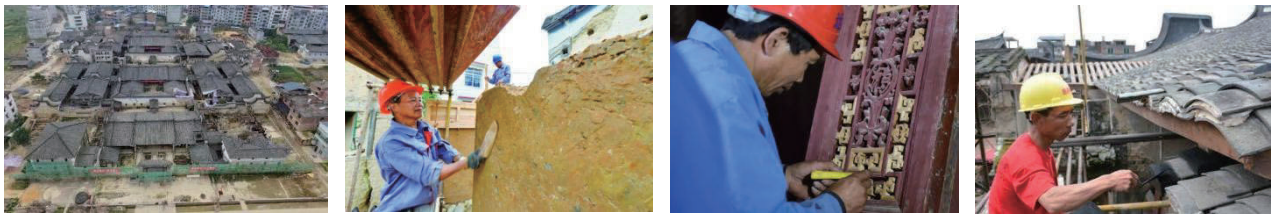
Table 1 Restoration Schedule[12)]

Date	Job Content
Before October 30, 2016	Complete desilting work of Honglincuo.
Before March 31, 2017	Complete the design of restoration plan for the damaged status of Honglincuo.
Before January 31, 2018	Complete the restoration work of door wall, academy of the first entry, and collapsed walls of the second and third entry of Honglincuo.
Before December 31, 2019	Complete full restoration of the damaged buildings of Honglingcuo.

b) All departments and units carried out the renovation engineering

The renovation engineering of Honglincuo was launched in October 2016 (Fig.8a), which mainly included desilting, debris removal, walls repair, tiling, roof repair, insect resistance, anticorrosion, wood members renovation, walls and floors repair and maintenance and decoration, etc[14)]. The environmental cleanup and repair and maintenance were carried out for buildings with slight damage. In terms of buildings with heavy damage, professional investigation and design institutions conducted detailed investigation and study on the damage of buildings, they formulated maintenance plans and submitted these plans for approval according to legal procedures before implementation. Since the rammed earth wall collapsed seriously in the typhoon disaster, the construction team first experimentally explored the building foundation structure, added cement to enhance the stability of the foundation, carried out the rammed earth wall technology test on the north side of the outer building, and used the old rammed earth wall technology to repair the damaged

wall (Fig.8b). At the same time, the tilted wooden buildings were righted and the collapsed ones were reinstalled. Additionally, the construction team also dismantled the brick and concrete structures built in the middle and late period of the second and third entry, and cleared the collapsed building rubble and wood, etc. In order to restore the historical appearance and pattern of Holnglincuo as much as possible, the restoration followed the principle of "repairing the old as the old". From the tiles on the roof to the carving of the eaves and the presentation of the hall, and to the paving of the floor, the original design style was followed and the original building materials and traditional handicrafts were used for the renovation [14] (Fig.8c, d).



(a) [13] (b) [13] (c) [15] (d)[16]

Fig.8 Renovation Engineering of Honglincuo

c) Active participation of the enterprises and the public

After learning of the severe damage to Honglingcuo, Fujian Tahoe Group donated 50 million yuan to protect the traditional cultural relic buildings. With the full support of the enterprise, the restoration of Honglingcuo received great attention and concern from all walks of life. Enthusiasm and great efforts of these groups accelerated the restoration progress significantly. Furthermore, the mutual trust and cooperation relationship between the management department of Honglincuo and the public were strengthened in the typhoon disaster. The local department not only established a new cultural tourism leading group to start the foreign investment promotion work, but also introduced colleges and universities, cultural and creative teams to promote the protection, activation and utilization of Honglincuo.

3. Problems and Suggestions in the Prevention of Typhoon Disaster Risk of Honglincuo

(1) Problems

a) Lacking of systematic disaster prevention and mitigation technology and specifications

At present, under the influence of wind disasters, the research on cultural relic disaster prevention and mitigation technology is relatively scarce and lagging behind, and the research on cultural relic buildings and surrounding environment is not in-depth enough, and no standardized and systematic risk assessment model has been formed. For example, in the renovation of Honglincuo, the period from the evaluation of the damaged cultural relic buildings to the implementation of repair and reinforcement plan is too long, which is easy to cause the secondary destruction of some damaged parts. In addition, Honglincuo is also relatively weak in the legal norms of disaster prevention and mitigation, and there is no relevant hard laws and regulations in place to guide wind disasters.

b) Lacking of a comprehensive and systematic understanding of disaster risk

The whole process of disasters that Honglincuo faces refers to the damage to cultural relics caused by the variation of its environmental factors, which consist of typhoon disaster-inducing environment (topography and landform, etc.), disaster-causing factors (strong wind and rainstorm, etc.), and disaster-bearing body. However, cultural relics such as Honglincuo pay more attention to all kinds of representation phenomena appeared after the disaster, they lack of research on the disaster-inducing environment and disaster-causing factors of typhoons, and the potential risk of typhoon disasters is ignored. There is also a lack of systematic

understanding on the difference of the damage mechanism and the disaster-causing process of different types of cultural relics in the face of typhoon disasters.

c) Lacking of overall thinking of cultural relic building protection and urban and rural development

Since the promulgation of the Venice Charter, the international protection of cultural relics is mainly based on reflecting their authenticity and integrity. However, at the current stage, the disaster prevention measures taken for Honglincuo and other historic buildings focus more on their value, which lack of thinking process of considering the cultural relic buildings, their surrounding environment and the development trend of urban and rural areas as a whole. There are certain limitations in the objects and scope of protection, and the methods and theories of protection are relatively weak.

(2) Suggestions and measures

a) Improving policy and law system and disaster prevention technology

Scientifically developing emergency plans for the prevention and mitigation of cultural relic buildings affected by wind disasters in Honglincuo, at the same time, introducing a law on the prevention and mitigation of cultural relic buildings affected by wind disasters. Strengthening the research and update of the disaster prevention and mitigation technology of cultural relic buildings under the influence of wind disasters, so as to ensure that relevant theories and methods aren't out of step with the world's leading level.

b) Establishing disaster preventive protection mechanism

Preventive protection measures mainly include sorting out and analyzing the disaster information collected by monitoring and identification, recognizing the causes and mechanisms of disasters, assessing disaster risks, and forming a regional wind disaster map for guiding subsequent damage assessment and disposal measures. First of all, the monitoring and early warning measures of meteorological departments should be strengthened. Secondly, the research on cultural relics'disaster prevention and mitigation technology under the influence of wind disasters should be deepened, the risk assessment models under different environmental scales should be established, so as to do a good job in disaster prevention and protection projects, and reduce disaster losses. Additionally, the post-disaster emergency management system should be improved, and the identification and evaluation before and during the disaster should be coordinated. The special emergency and disaster relief team should be established to deal with damage in different levels , and rescue protection and temporary reinforcement maintenance measures should be formulated to reduce the damage degree of cultural relics after the disaster, as well as to reduce the risk of subsequent disaster of cultural relics (Fig.9).

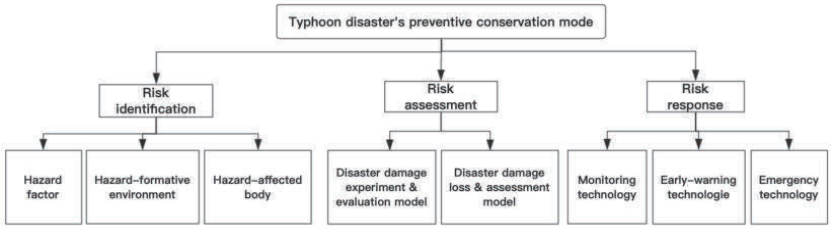


Fig.9 Preventive Protection Mechanism Map

c) Protection management and public participation

Carrying out detailed assessment of the mechanism of damage to cultural relics and working out plans for their renovation and protection. Through the establishment of a daily inspection mechanism, monitoring the renovation and protection of cultural relics in real time. Carrying out daily maintenance training, doing a good job in grassroots education and publicity, and coordinating the management of cultural relics and their surrounding environment.

4. Conclusion

Non-renewability and frangibility are two remarkable characteristics of cultural relic buildings. From the case of Honglingcuo' s response to typhoon disaster, we know that the national administration departments should firstly formulate a specific legal system of cultural relics disaster prevention and mitigation, and strengthen the research and update of cultural relics disaster prevention and mitigation technology under the influence of wind disasters; meanwhile, all departments should also actively establish the preventive protection mechanism of cultural relic buildings, starting from the three stages of pre-disaster, in-disaster and post-disaster, so as to reduce the damage degree of cultural relics after the disaster and the subsequent risk of disaster. In addition, the departments should pay attention to carry out daily maintenance training, do a good job of grassroots education and publicity.

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