

A Brief Discussion on Technical Points in the Restoration of an Ancient Building in Lanzhou City

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Abstract. With the change and development of The Times, the existing buildings are gradually aging and damaged, coupled with external objective factors and human factors, many building structures are seriously damaged or difficult to maintain the original architectural style. This paper will adopt Revit modeling and combine the principles of ancient building restoration and protection, take the restoration project of Tianqi Temple in Chengguan District of Lanzhou City as an example, analyze the damage of ancient buildings, discuss the reasons for the damage, focus on the analysis of ancient building restoration technology, simulate the construction process of ancient buildings, and provide reference for the future restoration and protection measures of ancient buildings.

Keywords: Ancient buildings, Restoration technique, BIM technology, Design principles

1. Introduction

China's architectural culture has a long history, but it is also because of the passage of time, many ancient buildings have been eroded by insects, wind and rain, and gradually weathered, and affected by technical problems and improper protection measures [1-3], a large number of ancient buildings cannot maintain their original features and are seriously damaged. Even now, many excellent ancient buildings have completely disappeared, and we can no longer see its magnificent scene with our own eyes, but can only look at its millennial-old style through pictures, which is a great pity for us. The state has issued relevant regulations on the protection and management of cultural relics, and has also made great efforts in the restoration and management of ancient buildings. At present, the restoration and protection measures of ancient buildings in China are improving day by day, and the protection of relevant ancient buildings has also achieved little effect, but there are still many ancient buildings that have not been well restored and protected. Therefore, we should pay attention to the restoration work of ancient buildings, constantly improve the restoration technology of ancient buildings [4-6], select and implement it in the restoration process, fully tap its scientific and professional nature, integrate the constantly developing technology into the restoration technology of ancient buildings [7-10], implement scientific and reliable management measures for the restoration project, and improve the restoration level. Starting from the principles of ancient building restoration and the problems existing in the current ancient building renovation and protection work, we can effectively improve the ancient building restoration technology, so as to achieve the renovation and protection of ancient buildings.

2. Principles and guiding ideology of ancient building restoration design

2.1 Design Principles

(1) Strictly abide by the principle of "not changing the original state", and preserve the historical original appearance and architectural characteristics of the renovated building as true and complete as possible. In the maintenance process, the traditional practice is the main restoration measure, the original building materials are used as much as possible, and the original building components are completely preserved.

(2) Strictly abide by the principle of "minimum intervention", protect and restoration measures to minimize human intervention on complete and stable components, with the main goal of continuing the status quo and mitigating damage. Conservation and renovation measures should only be used in the most necessary parts and reduced to a minimum to protect the cultural relics themselves and the historical and cultural information related to them.

(3) Strictly abide by the principle of "reversibility", complement the lost components, and use raw materials and original processes to complement the components according to the original shape and color; The reinforcement part should be connected reliably with the original structure and the original component, and the materials should be reversible.

2.2 Guiding Ideology

Implement the cultural relics work policy of "protection first, rescue first, rational utilization, and strengthening management", scientifically and reasonably solve the existing disease problems of Tianqi Temple, eliminate the hidden dangers of cultural relics insecurity, and create favorable conditions for better utilizing the comprehensive benefits of cultural relics, in accordance with the relevant laws and regulations of the state and the principles of cultural relics protection. To promote cultural relics protection and social, economic, cultural, ecological and environmental health, coordination and sustainable development.

3. Analysis of restoration technique of ancient building relics

3.1 Project Overview

Tianqi Temple, also known as Dongyu Temple, was originally located at No. 64 ~ 70 Zhangye Road, Chengguan District, Lanzhou City, moved to the present site in 1998. Covering an area of 1200 square meters, it sits north to south and is composed of three historic buildings and new walls, namely the mountain gate, the middle hall and the back hall. Tianqi Temple originally large scale, there are mountain gate, through the hall, middle hall, back hall, wing room and cross-yard, but to 1986 "two Pu", the temple only the mountain gate, front hall, back hall and damaged wing room and a "Tang Huai". Although some of the buildings were destroyed in the early years, the main buildings such as the nave and the rear hall that survived are shown in Figure 1, with exquisite structure, smart shape, exquisite decoration, and very local characteristics. As one of the representatives remains of Taoism in the Ming Dynasty in Lanzhou city, it has witnessed the vicissitudes of nature and society in Lanzhou city for more than 600 years, and is of high value to the study of the history of regional political, economic, cultural and architectural development.

During the relocation of Tianqi Temple, due to the improper use of building materials and restoration practices, insufficient maintenance during use, as well as natural precipitation, artificial green water infiltration and other reasons, some building components appeared different degrees of rot, fall off, shortening, weathering and other diseases. Among them, the uneven settlement of the foundation of the rear hall has caused the column and beam to pull the tenon, the gable to crack, the roof to leak rain, which directly threatens the safety of the building body.



(a) Gate



(b) Nave



(c) Rear hall

Fig. 1 Site of Tianqi Temple

3.2 Foundation restoration technique

According to the on-site investigation, the three cultural relics buildings of Tianqi Temple and

the foundation of the wall all have different degrees of settlement, as shown in Figure 2. However, except for the serious local settlement of the rear hall and the wall, the settlement in other areas is relatively slight. According to the principle of "minimum intervention" in cultural relic restoration, only the local foundation of the rear hall and the wall with serious settlement should be strengthened.



(a) Settlement crack in the east gable and



(b) settlement crack in the west gable

Fig. 2 Settlement crack diagram

The ground on the south side of the building due to long-term flooding subsidence, resulting in uneven settlement on both sides of the building (the south side is larger, the north side has no settlement), vertical cracks appear from bottom to top at the gable spine, the widest crack is 42mm, and the five beams connected with the spine mortise and tenon have appeared larger tenon phenomenon, endangering the safety of the wooden structure. The original foundation type of the proposed structure is reinforced concrete strip foundation, and there is no treatment of the underground loess silt soil layer. Because the loess silt in this site is collapsible loess, the collapsibility grade is IV self-weight collapsibility, and the maximum collapsibility depth is 21.0m. According to the second paragraph of Article 6.1.1 and the third paragraph of article 6.1.5 of the existing Building Code for Collapsible Loess Area GB50025-2004, part of the collapsible amount of the foundation should be eliminated for Class C buildings on the site, and the remaining collapsible amount of untreated collapsible yellow soil in the lower part after treatment should not be greater than 200mm. According to the calculation, the thickness of the treatment according to the requirements of the code is 15.0 meters. Because the building is a cultural heritage site, the foundation treatment process of dynamic compaction and compacted pile cannot be realized. Therefore, the existing building foundation is treated with slurry method according to the "Building Code for collapsible Loess Area" GB50025-2004, and strict waterproof measures are taken around it. Prevent the existing building from settling again.

3.3 Middle Hall, Mountain Gate Platform Foundation and Ground Restoration technique

The foundation and ground of the central hall and mountain gate: The indoor ground of the building is slightly damp and well preserved, while the blue brick paving of the terrace and front hall is acid alkali and severely weathered. In order to eliminate the root cause of the disease, the plastered bricks, cement plaster, and cement mortar cushion layer of the terrace and front hall are removed, replaced with a gray soil cushion layer, and the green ash joints are re paved; The settlement, cracks, and looseness of the platform, step stones, and step parts need to be partially demolished, re built, and filled with joints; Dismantle the existing cement mortar dispersion, redesign and cover it with building materials that match the ancient architectural style.

3.4 Rear Hall and wall (partial) restoration technique

Maintenance of the rear hall and surrounding walls (partial): Due to the new construction of a strip foundation and severe tenoning of components such as columns and beams, the rear hall was demolished, the roof was removed, and a large wooden frame was installed. After reinforcement, the overall elevation was carried out, and the foundation and anti-seepage treatment were carried

out; Partially demolish and rebuild the fence.

3.5 Overall in-situ support technique of large wooden frame in the rear hall

Before the large wooden frame in the rear hall is supported in situ, the wall should be removed first, the roof should be removed, the large wooden frame should be installed to pull the tenon part, and the large wooden frame should be strengthened (horizontal and vertical); Map the elevation of shaft net and column bottom, and then carry out in-situ support after marking on site. Supporting members can be selected channel steel, I-steel and other rigidity of the section steel. When supporting, it is still necessary to meet the force transmission mode of the wooden frame, and the main force support is located at the bottom of the column or the side of the column body near the bottom of the column as far as possible. Other auxiliary supports (e.g. beam or purlin supports) should only bear the weight of the member they support. The support scope must be outside the scope of the new foundation, and the specific support plan must be approved by experts before construction.

3.6 Roofing restoration technique

The roof is mainly composed of a wooden base, a tarpaulin back, a ridge, and tiles. Wooden base layer method: if the rafters are split by flying, they should be $\leq 5\text{mm}$, and if the oil or white is broken, they should be filled tightly with putty. If the thickness is greater than 5mm, dry old wooden strips should be used for patching, and epoxy resin adhesive should be used for bonding. After the adhesive is dry, the plane should be planed into an arc (flat with square rafters); The parts of the rafters that are slightly damaged by insects should be cut and scraped clean for anti-corrosion and insect prevention treatment (using ACQ-D wood anti-corrosion and insect prevention agent); When the depth of rafter flying debris is $\leq 5\text{mm}$, it should be tightly applied with putty along with oil decoration or broken white. When the depth of rafter flying debris is $>5\text{mm}$, it should be restored and treated with anti-corrosion according to the specific situation; According to the current material and specifications, replace the damaged and decayed eaves and tile openings, and treat the rafters with flying cracks, rain stains, decay, and insect infestations before making them white. Method of covering the back: 15mm thick hemp knife protective board ash \rightarrow 80mm thick mixed with plaster back \rightarrow 40mm thick tile base slurry mud \rightarrow apply "tie shoulder ash" on the ridge \rightarrow fix the tile and press the shoulder, catch the joint and clamp the ridge; The construction method of the roof from bottom to top is as follows: rafters \rightarrow cover plate (20mm thick, 200mm wide) \rightarrow flying rafters covered with back (15mm protective board ash and 80mm mixed with plaster from cover plate to top) \rightarrow tiled roof (100:3 small hemp knife ash), and the tile construction method is "6 pressed and 4 left"; According to the size and specifications of existing tiles, hooks, and animal parts, restoration cracked, lost, detached, inconsistent tiles, hooks, animal parts, and detached ridges; Remove the tiles and spray them with a 3% hexazine solution.



(a) Cracked roof ridge



(b) damaged tile surface

Fig. 3 Details of the roof

3.7 Drainage and hospital environment improvement

Drainage organization design: Most of the diseases in Tianqi Temple are caused by stagnant water. Open ditch drainage design is adopted to solve new diseases caused by stagnant water in the

hospital. Open drainage ditches should be set up along the east and west sides of the building in the courtyard, drainage holes should be dug at the lower end of the south wall to drain the water in the courtyard, and open drainage ditches should be dug outside the courtyard to drain the rainwater in the courtyard to the south side of the mountain gate 10 meters away.

Environmental improvement in the courtyard: Remove the trees close to the east side of the nave and the lawn in the courtyard; Excavate the 250mm soft ground in the hospital and consolidate it, and then do 3:7 lime soil step, 40mm thick 4:6 mixed plaster base, 310×155×65mm blue brick parallel cross seam rough, 4:6 gray sand sweep seam; Mountain gate, middle hall, back hall building water use 320×320×60mm green square brick parallel cross seam rough, 4:6 gray sand sweep seam.

3.8 Restoration effect

In the actual process of renovation, the basic principles of minimal intervention, no change in the original state of cultural relics and reversibility were strictly followed. The project was modeled with Revit as the main body and assisted by Lumion, FZUOR, pr and other software to transform ancient buildings into interesting digital works. Three-dimensional models are used to display the image of ancient buildings, as shown in Figure 4. It has played a very important role in the renovation and later protection of cultural relics, and successfully completed the construction task, and the final restoration effect is ideal, and the overall effect meets the design requirements. It retains the original architectural style of Tianqi Temple and eliminates the hidden safety risks of the building.

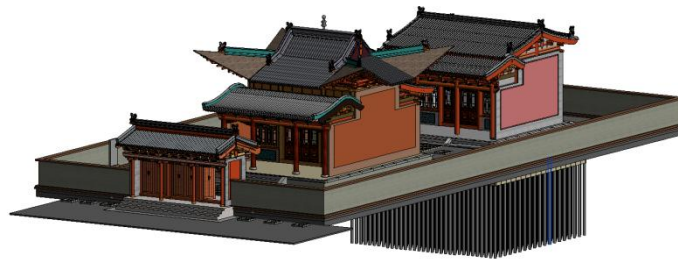


Fig. 4 Cloud picture of Tianqi Temple

4. Summary

This paper takes the renovation project of Tianqi Temple in Chengguan District of Lanzhou City as an example to discuss the renovation technology of ancient buildings. The protection and display of ancient buildings by BIM technology is an important supplement to the protection and inheritance of cultural heritage and an inevitable trend of the development of ancient buildings protection. However, the current protection of ancient architectural relics in China still needs to be improved, and the technical level of renovation and protection is still relatively insufficient. In view of these problems, relevant personnel should actively study and explore the renovation, protection and utilization path of ancient architectural relics, and provide more strategies for ancient architectural relics to play more historical value. In addition, as an important part of China's excellent traditional culture, the exploration of ancient architectural relics restoration technology is also an important path to promote the inheritance and development of excellent traditional culture.

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