Application Research of BIM Technology in Ancient Architecture Restoration

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Abstract. At present, the history of Chinese ancient architecture has a long history and independent development. As early as The Shang Dynasty, Chinese architectural system has been initially formed. Until the beginning of the 20th century, it has always maintained its own structure and layout principles, and has been widely spread to other countries. BIM Technology is a rapidly rising digital modeling technology in recent years, which is widely used in the construction industry. Its intuition and accuracy have become the advantages of its rapid development. At the same time, BIM Technology can also better protect ancient buildings from the perspective of information. Starting from the ancient building restoration industry, this paper analyzes the current development trend of the domestic ancient building industry, and summarizes the key problems existing in the existing ancient building restoration methods. This paper analyzes and discusses the advantages and functions of BIM technology. According to the example of the old office building of Fengtian Zhaoxin Kiln Company, a BIM model is established. Starting from the application of BIM technology in survey and design, construction process management and repair of special parts, the actual application of BIM technology in ancient building repair is discussed, and valuable results are obtained.

1. Ancient building restoration industry

Ancient buildings are the carriers of cultural heritage in various regions. People can understand many different cultures through ancient buildings. In order to reduce the damage of human factors to historical buildings, which leads to the damage of the value contained in buildings, China began to pay attention to the protection of cultural heritage in the 1930s. With the development of related industries, China held the first seminar on the history of modern Chinese architecture in the 1980s and promulgated the Law of the People's Republic of China on the Protection of Cultural Relics. At present, China's historical building protection has achieved remarkable achievements in the theoretical field and accumulated rich experience in practice¹².

2. Existing Repair Methods and Their Problems

According to relevant theoretical and practical experience, the general process of ancient building protection is divided into preliminary investigation, value evaluation, current situation investigation, technical analysis, preliminary design scheme, formulation of plan progress, optimization of relevant scheme, design review and approval, application of restoration scheme to construction.

Like other cultural relics, the greatest value of ancient buildings lies in that they are remnants given to us by the long history and cannot be regenerated. Once destroyed, they cannot be retrieved. Even if
conditions permit, the historical value of ancient buildings is greatly reduced compared with the original. However, the existing restoration methods are due to the extensive use of modern building technology, including construction technology and building materials. Therefore, in the process of restoration of ancient buildings, due to the intervention of modern science and technology, we often destroy the historical value of ancient buildings to different degrees.

3. BIM Technology

3.1. Introduction to BIM Technology
BIM is called "Building Information Modeling", which is a kind of technology that presents and stores digital, information and visual building models. When we use BIM information technology, we can collect relevant data and carry out information analysis of data through computers to obtain all aspects of building information we need.

3.2. Advantages of BIM Technology
(1) High Flexibility
In the process of ancient building restoration, BIM technology can quickly establish relevant building models through electronic information means, and import relevant materials, construction technology and other information of the structure. In other words, BIM technology can provide a targeted, easy-to-modify and easy-to-analyze intuitive data model, which can quickly help us understand buildings and determine construction schemes, while significantly reducing potential safety hazards.

(2) Strong Digital Management
Using BIM information technology in the ancient building restoration industry can integrate the data we collect and store it in digital form. In the specific management process of ancient building construction, digitalization can often make the restoration work more accurate and efficient, and at the same time promote the further development of China's ancient building restoration industry and move towards more developed digitalization and informatization. When making drawings, BIM 3D drawings are often more intuitive and accurate than traditional drawings, which is convenient for relevant personnel to obtain information. At the same time, digitalization can also facilitate the sharing of information resources to a great extent and speed up the development process of the entire industry.

(3) Strong advanced simulation and analysis and prediction functions
The quality of ancient building restoration and development projects often depends on many factors such as the surrounding environment, social impact and industry trends. With the help of BIM technology, we can collect and analyze relevant data more comprehensively to obtain targeted pre-judgment results and provide accurate direction for restoration work.

4. Application of BIM Technology (Taking Fengtian Zhaoxin Kiln Company Office Building as an Example)

4.1. Overview of Repair Works
The former office building of Fengtian Zhaoxin Kiln Company is located at 92 Huigong Street, Shenhe District, Shenyang, Liaoning Province. As shown in Figure 4, it is now used by Shenyang Taiwanese Businessmen's Guild Hall and belongs to immovable cultural relic of Shenyang. In the past, the building was also called "Du Mansion".

The building is above the financial center station of Shenyang Metro Line 2. During the construction of the subway station, in order to avoid damage to cultural relics, the station design was dislocated from the foundation of the building to protect the structure of the building. Therefore, at present, when carrying out restoration, we should not only consider the full consideration of cultural relics, but also consider the impact of subway stations, in line with the relevant subway management regulations.
4.2. Application of BIM Technology in Survey and Design

The traditional simple observation method is to draw a baseline along the side of the higher parts when measuring them. According to this baseline, the steel ruler (the steel ruler is not suitable for deformation and has high measurement accuracy) is used to measure the bending scale and the distance between the parts. At the same time, the length of the related parts (the distance from the center line to the center line) is also required to facilitate calculation and analysis. Its shortcomings include complicated steps, large errors, inaccurate data, time-consuming and laborious.

When the traditional simple observation method is used to observe the office building of Zhaoxin Kiln Company, due to its European-style columns, including column head and column body. In addition, the building also contains porch windows and walls in the style of ancient Chinese buildings, with relatively complicated structure. On the ground floor of the building, there is also the financial center station of Metro Line 2 in operation, so it is difficult for traditional observation methods to observe the required data in detail.

When we apply BIM technology to observation, we use observers to collect the damage of buildings, export and summarize the data, and use REVIT and other software to make a building status model, which can not only quickly obtain detailed structural data, but also obtain more accurate data, which is more helpful for us to repair the building.

Related to this is the new technology LiDAR remote sensing, which was developed earlier in the field of cultural relics protection. The emergence of LiDAR remote sensing, which is a key application field, provides technical support for the protection of architectural cultural relics, can quickly and efficiently obtain specific information on the surface of the measured object, and avoids secondary...
injuries. Point cloud data can be used to establish fine three-dimensional models, restore the structural state of architectural relics, and provide data support for later archiving and restoration. Topographic map mapping uses LiDAR remote sensing and post-processing software, and only needs simple operations such as data acquisition, splicing and conversion to obtain large-scale topographic maps. Compared with the traditional field data measurement using total station, LiDAR remote sensing has the advantages of high efficiency, complete content, diversified results and intelligence.

When repairing the office building on the former site of Zhaoxin Kiln Company, we used LiDAR remote sensing to measure the cracks and deflection of the beam and slab of the house, and measured the subway station position below, collected relevant data and constructed a three-dimensional model. Considering the influence of the subway station, the relevant positions of the subway station should be drawn at the same time to show the restoration construction environment more intuitively[3].

4.3. Application of BIM Technology in Construction Process Management

Building construction simulation is divided into two aspects: construction progress and real-time construction. Construction progress simulation is to generate dynamic and intuitive visual simulation results by importing a series of relevant data and using digital technology, which makes process connection and construction progress more reasonable.

Real-time construction simulation means that, in the actual construction, through the collection and analysis of real-time data, the comparison and analysis of the planned time and the actual time are carried out, and the cooperation scheme of personnel is regulated and controlled at any time to analyze whether the process is reasonable, which has more accurate guiding significance for the construction progress.

4.3.1. Schedule Control

Before repairing the office building of Zhaoxin Kiln Company, BIM technology should be used to make an overview of the construction plan, list each step of the construction process, and make a specific analysis of each stage, allocate the supply and utilization of resources in each construction step, so as to maximize the efficiency.

The capital resource curve shows the contract budget and cost budget of each construction cycle in the construction simulation. The displayed curve represents the planned cost, actual cost and the deviation between the two. According to the curve distribution, optimize and adjust the construction schedule in time to ensure the normal operation of the actual construction[4-5].

4.3.2. Resource Control

In the process of construction, our repair work requires various materials supply and resource mobilization, so in all links, there are higher requirements for resource control. Not only should the procurement of related materials and materials be considered in the early stage, but also the materials needed to be supplemented and adjusted during the design process.

In the process of ancient building restoration, if the wall is renovated or even masonry, it is necessary to continuously purchase relevant materials and collect relevant demand data. Through BIM5D simulation analysis, the required demand for cement, blocks, bricks and tiles and other materials is obtained as the procurement support data for the early stage of the whole restoration work. On-site control based on digitally analyzed data can effectively improve efficiency and transport in place at one time, which is conducive to more refined management of related resource allocation and capital flow.

4.4. BIM Technology for Special Component Repair

In the former office building site of Zhaoxin Kiln Company, there are still many special parts repair work, which includes two situations: one is to replace the parts on the original building that are not completely damaged but have unreasonable design or do not conform to modern building codes, which belongs to replacement repair. Second, under the condition that some parts of the building are
seriously damaged or even completely disappeared, through the integration of digital information, the appearance of the relevant parts should be obtained through analysis, and the repair is duplicated and repaired, which is missing repair.

4.4.1. Complex Node Repair
Many ancient buildings involve many kinds of special and complicated component nodes, such as the circular dome and parapet decorations of the office building, which are complicated in structure and difficult to construct. Before repairing it, BIM model can be established for the dome structure according to the construction drawing to simulate the repair process, and then the arc dome model can be printed in 3D to generate a specific device scheme diagram, which is convenient for on-site repair and installation. With the help of BIM modeling, the precise component size is more accurate, the prefabrication of components is more standardized and accurate, the efficiency is improved, and the cost is saved on the premise of ensuring the construction effect. In addition, the establishment of BIM model and the simulation of construction process can show the relevant information in construction in more detail and more vividly, which can greatly reduce knowledge barriers and achieve more effective communication when researchers in different fields communicate.

During the repair process, we will model and record the specific components of relevant buildings, and gradually enrich the relevant building database. The perfection of the database will not only make the engineering evaluation in the later stage of our repair more efficient, directly display the information of relevant components, and carry out fast and accurate evaluation, but also be of great help to the development of the whole industry. The partition wall of the building has complicated occlusal relationship and special connection form, including brick structure jointing, the repair principle seems simple, but the actual operation is difficult to achieve satisfactory results, which is very easy to cause rework. As a building with a combination of Chinese and Western styles, the office building has a complex structure and high requirements on component contour and component occlusion. When making models and constructing digital information, staff can adjust the scheme and optimize the design structure of relevant complex nodes at any time. For example, the cross relationship of triangular structures on parapet decorations can be simulated to deal with the occlusion relationship between components more precisely, thus greatly avoiding the situation that the actual components cannot be repaired due to the over-idealization of the scheme and the large amount of occlusion and interweaving and difficulty in operation. BIM's restoration simulation of complex nodes in ancient buildings not only collects digital information to make the model more precise, but also solves many possible problems on paper and corrects the scheme in time. In addition, accurate modeling of each node can also optimize the construction process and is conducive to on-site disclosure. With the wide application of BIM technology, a solid foundation has been laid for the
"component resource bank" and "construction operation guidance" in the ancient building restoration industry in China.

4.4.2. Brick Wall Reinforcement Treatment

The core problem of ancient building wall protection lies in wall load-bearing reinforcement and brick surface repair.

When the brick wall masonry is damaged, due to the intelligence of the rotating block to bear the load, in order to ensure the safety and stability of the building, it is necessary to replace the brick masonry with insufficient firmness. BIM technology can be used to model the relevant masonry before replacement to ensure that the replacement masonry is basically consistent with the original masonry. At the same time, digital stress analysis can also be carried out to calculate the load-bearing safety, which greatly ensures the rationality and safety of the scheme.

According to the damage of the whole building and the judgment of the safety performance of the building, for wall surfaces requiring large-area "brick replacement", BIM construction simulation automatic brick arrangement technology is adopted, and brick simulation and fine arrangement are carried out according to the original brick wall parameters (block size, mortar joint thickness and side joint lap length) and brick arrangement methods during masonry (one in line with one in line, all in line with one in line with the other). As a BIM brick row pilot project, this project compares BIM brick row volume with GCL budget model volume, and the data difference obtained is as high as 7.73%, which greatly saves costs and improves internal control capability.

After BIM simulates brick row, the corresponding schematic diagram and information data table are derived, which can not only make technical correction to the whole repair project to ensure the masonry quality of brick wall, but also provide data support for brick preparation, thus killing two birds with one stone.

5. Conclusion

(1) This paper discusses the current situation of the ancient building restoration industry, finds out the existing problems in the industry, and through the comparison between traditional technology and BIM technology, discusses the solution to the problems after BIM technology is applied to the ancient building restoration.

(2) Combined with the office building of Zhaoxin Kiln Company, this paper discusses that BIM technology can improve the accuracy of repair work, digitally manage the construction progress, repair complex joint parts and wall cracks in a targeted way, and effectively manage the resources of the project.

(3) When BIM technology is integrated with the restoration of ancient buildings, the industry will have more prospects for development and make outstanding contributions to China's strategy of becoming a cultural power.

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