Analysis of the Application and Limitation of Building Information Modeling (BIM) Technology in Yunnan Cultural Heritage Inheritance and Preservation--Take the Stilted Building as an Example

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Abstract. Nowadays, the digitization of cultural heritage is drawing more and more attention. A large number of studies are trying to combine cultural heritage protection with modern technologies such as video, virtual reality technology and 3D models, so that cultural heritage can be protected and inherited. Based on the background of the digital inheritance of cultural heritage, this study takes stilted buildings of ethnic group Zhuang, a traditional dwelling of ethnic minorities in Wenshan, Yunnan, as an example. Via literature review method, field inspection method, questionnaire survey method, interview recording method and Revit software, a modeling analysis of stilted buildings is carried out, in order to figure out the contribution and limitation of BIM technology in cultural heritage protection. The study found that the visualization, simulation, information sharing and the establishment of "group" play a significant role in the protection and development of Heritage Building Information Modeling. However, the application of BIM technology is still in the preliminary research stage and has not been popularized in the field of cultural heritage protection and inheritance.

Keywords: Cultural Heritage, Stilted Buildings, Maintain, Preserve, BIM , Family, Model.

1. Introduction

1.1 Current situation of cultural heritage inheritance and protection

Cultural heritage is facing a crisis of forgetting. Lowenthal D (1997) [1]and Shkalenko A.V. (2020) [2]wrote that in the torrent of time, after two world wars, due to the industrial revolution and the baptism of information technology, most of the cultural heritage was damaged or gradually forgotten. Some have disappeared. Facing the crisis of the gradual disappearance of cultural heritage, some countries do not have enough ability and technology to preserve and inherit cultural heritage.

In response to the crisis of disappearing cultural heritage, people began to study the digitization of cultural heritage. It is a great way to integrate existing emerging technologies with cultural heritage(Liu, 2014)[3]. Through transforming cultural heritage into the data, storing it into the "cloud", classifying and archiving, and sharing it on various platforms, cultural heritage can be inheried and delivered (Marta, 2018; Wang & Peng, 2017)[4-5].

Based on this background, this paper takes the Zhuang stilted building, a traditional dwelling of ethnic minorities in Wenshan, Yunnan as an example. BIM technology is applied to the modeling of stilted buildings for research, in order to discover the significance and limitation of BIM technology in the protection and inheritance of cultural heritage.

1.2 The current status of protection technology and inheritance for stilted buildings in Yunnan

Stilted buildings have gradually been phased out and disappeared in recent years. The reason is the limitations of the repair technology for stilted buildings. On the basis of the reason of "Restoring the Authenticity" in the existing law, stilted buildings need to be maintained and protected like their previous appearance, which means "the new building will be showed like its old look". According to Li et al. (2019)[6], some corresponding measures to build and maintain stilted buildings were

recorded according different components of stilted buildings. Nowadays, due to the pressure of life and economy, as modern locals gradually ignore the traditional construction technology of stilted buildings, the number of craftsmen who built stilted buildings is rapidly decreasing and the construction skills are facing lost.

Another reason is the lack of raw materials and the impact of modern building materials. Cao et al (2017) [7] mentioned that traditional building materials had a short service life compared with modern building materials. It is quite difficult for locals to maintain their buildings by the traditional raw materials. Instead, it is easy to collect modern building materials such as bricks and concrete. Modern building materials are not only convenient but also efficient for the whole building process.

In addition, locals' demands on high quality of life is getting increased as the changes in their lifestyle. For example, Tang (2000) noted that the dimly ray-less living environment of stilted buildings did not meet the living requirements of current residents and modern people's requirements[8].

To various reasons, stilted buildings are gradually disappeared in people's life in Yunnan.

1.3 Aim

The purpose of this study is to apply BIM technology to the preservation of conventional ethnic buildings in Yunnan in order to discover its contributions and limitations in the preservation of tangible cultural heritage and intangible cultural heritage.

2. Methodology

2.1 Field investigation method

The data of on-site inspection method is more time-sensitive and can more accurately reflect the changing trend of the market. Qing (1996) pointed out that field investigation method has the following advantages[9]:

(1)Goal clarity;

(2)In the field trip, with questions, combining field trip and reading, and being able to talk closely with local residents, you will get some important information;

(3)Field investigation can reveal many natural causes and increase the scientific nature of the data.

Based on this research direction and research background, Zhetu Township, Guangnan County, Wensan Prefecture, Yunnan Province, was selected as the inspection site after comprehensive consideration. There are a huge number of stilted buildings and Zhuang ethnic people in the town. The ethnic living form is in the form of "large mixed living, small living together", plus the traditional Zhuang residential stilted buildings, forming a unique group of stilted buildings with ethnic characteristics. Due to the backward economic development and the current government's protection policy, it has more stilted buildings preserved.

The terrain of Zhitu is high in the northeast, low in the southwest, belongs to the subtropical monsoon climate and the average temperature is about 16 degrees Celsius. The geographical location of the township is given by Figure1 and Figure2.



Figure 1. Map of China for the location of Beijing, Kunming, Guangnan (source:https://22092042.s21i.faiusr.com/2/1/ABUIABACGAAg_eaN8wUowN-G0QYwtC449yA.jpg)



Figure 2. Yunnan part map for the relative location of Kunming, Guangnan and Zhetu village (source:Yunnan yesbook)

2.2 Interview recording method

Interview recording method is a planned conversation with the unequal role status of the interviewer in order to understand the information and verify the hypothesis. The interview method focuses on interviewers and interviewees who are related to social phenomena investigated (Yan, 2002)[10]. The advantage of the interview recording method is simple, which the requirements for personnel are not high. Interviewees can be interviewed in a targeted manner or in a wide range.

In this interview record, targeted interviews are the craftsmen who participated the construction process of stilted buildings, and large-scale local residents, including young people, elder people, children and groups. The main purpose of this interview is to learn the construction process of stilted buildings and the construction techniques of traditional stilted buildings. The main inspectors were four village committees and five natural villages in Tuxiang, a total of five professional craftsmen, and two times Group interview.

Interthe craftsman are asked for four questions as follows:

Suspension building construction process;

The materials used for the stilted building;

Members and dimensions of stilted buildings;

Difficulty in the construction process.

There were no clear questions in the two group interviews, but the main purpose of the two interviews was to understand the attitude whether to understand and accept the protection technology for the inheritance of stilted building .

2.3 Questionnaire survey

Yang Lizhu, a professor at the School of Psychology of Liaoning Normal University, believed that "the questionnaire method is a method for researchers to divide the topics into detailed categories, to formulate a series of simple and easy questions, to compile a standardized questionnaire, and to conduct statistical treatment and to draw conclusions according to the recovered answers" (Liu & Wu, 2018)[11].

The purpose of this questionnaire is to investigate the local people's understanding of the inheritance and protection status of stilted buildings. Questionnaire distribution is a targeted distribution, and the questionnaire distribution site is the investigation site. Eleven questions were designed overall, and the questionnaire was sent out online, and 65 valid questionnaires were collected. At the same time, it is considered that some elderly people do not use mobile phones, so the elderly was asked orally one by one and the author filled the electronic questionnaire in person.

2.4 Model analysis method

In this study, Revit software was used to model the stilted building. Revit is the main software of BIM, and the family function of Revit plays a major role. Using the Revit model analysis method is

to discover the construction characteristics and technical difficulties for the stilted building. The reason why the components of the stilted building need to be established separately is that the stilted building is mostly a bucket of arches and tenon-and-mortise structure, which is different from the connection method of modern concrete. Each column of a stilted building is different, each column has multiple sockets, and the positions and directions of each socket are different. These characteristics can be found in the modeling process.

3. Results

3.1 Questionnaire results

An analysis of the returned 65-point questionnaire found that the locals were very interested in inheriting the stilted building. They believe that with the strong support of the government, the maintenance of the stilted building complex can be preserved to develop local tourism. This will not only drive local economic development, but also publicize and proserve local stilted buildings.

3.2 Main components of the stilted buildings

Through field investigation and interview records, it is found that the stilted building is mainly connected by several large roof trusses. Large roof frame members can be divided into vertical members and transverse members.

The vertical members, including the main column, the secondary column, the eaves column and the riding column, are all made of wood. The main column, the secondary column and the eaves column belong to the floor column, and the floor column is placed on the pile foundation stone. The riding column is placed on the square-beam, and the specific vertical components are presented by Figure 3 and Figure 4.

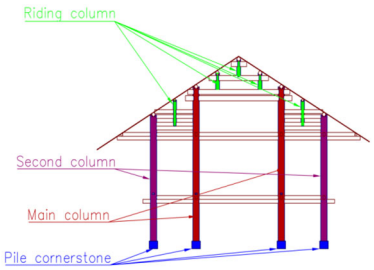


Figure 3. Vertical member of roof frame

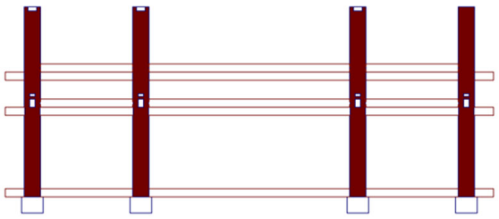


Figure 4. Vertical of eaves

The transverse component of the large house frame is mainly square-beam. The function of the square-beam is to connect the columns and evenly distribute the load on the columns to the ground. The square-beam are further divided into foundation square-beam, first square-beam, second square-beam, five-purlin square-beam and three-purlin square-beam, pnentrating square-beam, cantilener square-beam presented by Figure 5.

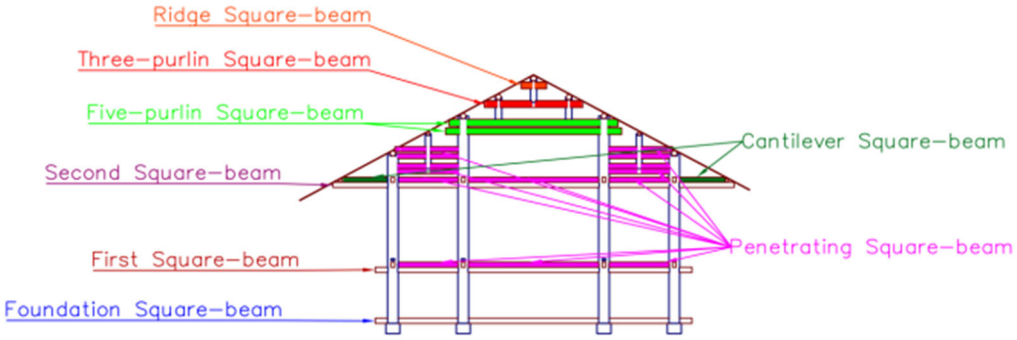


Figure 5. Square-beam

Other landscapes including purlins and rafters are presented by Figure6. In addition to the purlins and rafters, there are various components connecting the large roof trusses Purlins and rafters, which belong to the components of the roof. The purlins are placed on the main column, the secondary column and the riding column. The rafters are placed on the purlins to form the roof carrying tiles.

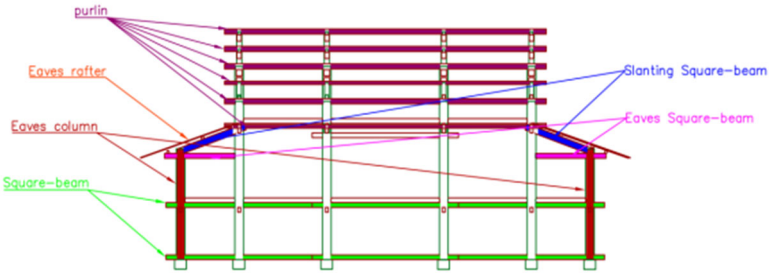


Figure 6. Roof truss connection diagram

3.3 Model analysis

The "family" of Revit simplifies complex wooden structures, constructs buildings and classifies these components, and then assigns corresponding parameters to these family models to build ancient building models, and can effectively record the basic information of ancient building ontology (Shi et al.2014)[12]. Therefore, during the process of establishing the stilted building model, it is necessary to first construct the components of the stilted building using the family function, and to set parameters for the components, so that they can be used directly next time.

During the modeling process of stilted building, the entire process follows the traditional stilted building. The first step is to insert the previously built main column, secondary column, eaves column and various families into the project to construct the large roof truss. The second step is to use other trusses to connect each large roof truss horizontally, thereby establishing the main frame of the stilt building. The third step is to install the purlins and rafters on the columns, to build the roof frame, and to cover the tiles regularly. Finally, it is the installation of shielding and decoration such as hoardings, floors, and stairs. The modeling process of the roof frame is presented by figure7 and the entire model is displayed by figure8.

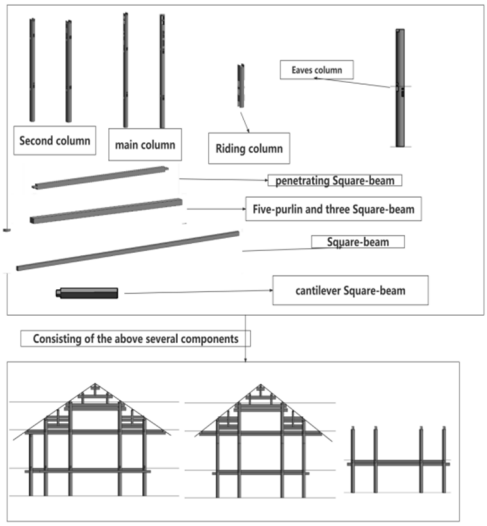


Figure 7 The component process of the house frame

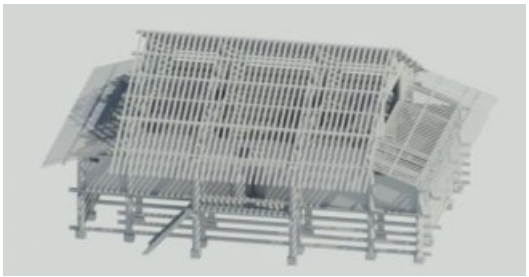


Figure 8 Entire Model of Stilted Building

4. Conclusions

4.1 Conclusion

Through the data of questionnaire survey and interview records, it is analyzed that the residents of the inspected area understand the current situation of the stilted buildings. Local residents are also full of support and expectations for the future development of stilted buildings. The preservation and inheritance of stilted buildings have been developed with the cooperation of the government and locals, and most of the stilted buildings have been preserved. However, a problem arose, which is the craftsmen who built stilted buildings gradually disappeared, and there was a lack of skills inheritors.

Combined with the results of the model analysis method and the interview recording method, the technical difficulties and characteristics of the stilted building are found. Stilted buildings are generally a tenon-and-mortise structure, which is a common connection method for traditional Chinese wood structures. The technical difficulty lies in the various forms of columns. Each column per stilted building is different, which cannot be set and processed in batches, but can only be processed respectively according to the different size of roofs.

This study found that BIM technology has advantages and disadvantages in stilted building modeling. The advantage is that errors can be found and corrected in advance, reducing errors in actual construction, while direct processing may lead to material waste, or the use of incorrectly processed columns directly affects the aesthetics of the building. After the modeling is completed, the software can see the complete and complex column form, so that it can be processed according to the pillar shape on the model. The disadvantage is that there is no dedicated “family bank”, and it takes a lot of time to new model a stilted building components.

To sum up, BIM technology can effectively digitize Yunnan cultural heritage, share data, visualize ancient building models, and establish complex components of ancient buildings. However, its limitation is that the technology is yet widely used in the protection and inheritance of cultural heritage.

4.2 Future resarch

The further study of BIM technology in cultural heritage makes it suitable for the modeling of most architectural heritage. It makes the modeling of architectural heritage faster and easier. It can also be combined with modern technology to make the pre-modeling mapping, modeling process, and modeling material manufacturers provide integration. Looking forward to the much more achievement of BIM technology in the inheritance and protection of cultural heritage in Yunnan and even in the whole of China.

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