Application of BIM technology in prefabricated buildings

*Jingjing Liu 1,2 and Zuxu Zou 1
1School of Civil Engineering and Architecture, Wuhan Polytechnic University, China
2Corresponding Author: liujingjing@whpu.edu.cn
3No. XG2020006, Wuhan Polytechnic University, China

Abstract. Based on the disadvantages of the current traditional construction mode, this paper analyzes the status quo of the gradual disappearance of demographic dividend and discusses the necessity of developing prefabricated buildings. This paper elaborates the advantages of applying BIM technology to prefabricated buildings in theory. Finally, the application of BIM technology in prefabricated buildings is demonstrated by introducing the construction process of a prefabricated community project. Through the example demonstration, it can be seen that BIM technology integrates all the information of the construction project, which can not only standardize the construction site and make the structural design more efficient, but also provide an efficient platform for communication among various parties. This exploration plays a positive role in promoting the popularization and development of prefabricated buildings.

1. Characteristics and development of prefabricated buildings in China
As the world's largest construction market, China completes about 2 billion square meters of urban and rural construction each year, including 600 million square meters of urban housing. Compared with developed countries in the world, China's construction industry has many problems, such as low degree of industrialization, long construction time, high energy and material consumption. At present, the production cost of China's construction industry is rising, among which the rise of labor cost is an important factor. As shown in Figure 1, comparing 2003 with 2018, the wages of skilled workers have increased by 434% over the past 15 years. With the birth rate falling, you can expect labor costs to continue to rise and the number of skilled workers to decline. This trend makes it necessary to reduce the use of labor and improve the quality and efficiency of construction by means of construction industrialization [1].

Prefabricated building refers to the structure system, external envelope system, equipment and pipeline system, internal decoration system of the main part of the building using prefabricated components. In general, the wall panels, stairs, floor slabs, beams, columns and other components of such buildings are prefabricated in factories [2]. The implementation of prefabricated buildings can achieve industrial production and effectively reduce the use of labor. The prefabricated building can improve the design precision and construction efficiency through the standardization design in the early stage. Reasonable use of prefabricated building engineering can play a great role in component quality, construction safety and on-site environmental protection.

Research and development of new prefabricated buildings that meet the requirements of construction industrialization, save labor and time, good construction quality, energy saving and environmental protection, has become an important task to promote the development of construction industrialization in China.
In February 2017, the General Office of the State Council issued the document "Opinions on Promoting the Sustainable and Healthy Development of the Construction Industry", proposing the development of prefab buildings in standardized design, factory production, assembly construction, integrated decoration, information management, intelligent application and other aspects [3].

Figure 1. Average salary of urban employees in China's construction industry from 2003 to 2018.

2. BIM technology development status in China

BIM refers to "Building Information Modeling". The traditional way of information exchange is through the software between the point - to - point way to transfer. BIM changes the traditional mode of information exchange by building an electronic information platform, so that all participants can exchange information through the information platform. BIM technology enables all parties to implement collaborative operation and parallel management in the project, which fundamentally changes the project construction and operation management mode. Compared with the traditional architectural design mode, the intervention of BIM technology can better achieve the improvement of work efficiency and quality, reduce errors and risks, and significantly reduce costs.

Compared with many other developed countries, BIM technology research in China started late. The application of BIM technology is limited by the project management mode and level of construction enterprises, and it still faces many practical problems. China has always given policy support to the promotion of BIM technology. On February 15, 2019, China issued a notice entitled "Key Points of Work in 2019 of the Department of Engineering Quality and Safety Supervision of the Ministry of Housing and Urban-Rural Development", which explained how to effectively use BIM information technology and proposed government support for BIM software development in the notice.

3. The meeting point of prefabricated building and BIM technology

3.1. Prefabricated buildings cost more than traditional buildings

Prefabricated buildings save a lot of resources in the construction stage, and the statistical results are shown in Table 1. This is where the prefabricated building has an advantage over traditional building methods.

Table 1. Comparison of resource consumption between prefabricated building and traditional construction

| Statistical categories                  | Prefabricated building | Traditional construction | Percentage reduction |
|----------------------------------------|------------------------|--------------------------|----------------------|
| Energy consumption per square meter(Kilogram standard coal/m²) | 15                     | 19.11                    | 21.5%                |
| Water consumption per square meter(m³/m²)   | 0.53                   | 1.43                     | 62.9%                |
| Formwork per square meter(m³/m²)         | 0.002                  | 0.015                    | 86.7%                |
The amount of garbage produced per square meter ($m^3/m^2$) is shown in the table below:

|                | 0.002 | 0.022 | 90.9% |
|----------------|-------|-------|-------|

However, we analyzed the cost data of some completed prefabricated shear wall structures in China and found that the construction cost of prefabricated buildings is higher than that of traditional buildings. In Figure 2, we express the correlation between the building assembly rate and the cost increase of prefabricated buildings. Although the curve decreases when the assembly rate exceeds 65%, indicating that the construction cost decreases with the increase in the assembly rate, it is true that prefabricated buildings are more expensive. This could hinder the spread of prefab buildings.

![Figure 2. The correlation between building assembly rate and construction cost increase.](image)

3.2. **BIM Technology can reduce the cost of prefabricated buildings**

There are two main reasons for the high cost of prefabricated buildings. One is that the main structure uses a large number of prefabricated components. In addition to the production cost of components, the cost of prefabricated components also increases the amortization cost of production equipment and transportation cost of components. Second, China's current construction methods and levels are still in the extensive production stage, the existing management means and mode are not suitable for the construction of prefabricated buildings. Reducing the cost of prefabricated components can be realized by expanding the production scale of assembled components. To improve the management level and achieve fine management, BIM technology is needed to help.

In 2019, Dajiang Wu discussed the principles of the integrated application of BIM in prefabricated buildings, and introduced the application of BIM in each stage of prefabricated building construction in combination with specific projects. His research shows that BIM can realize the integrated application and whole-process management of prefabricated buildings, effectively ensuring the efficient implementation of prefabricated buildings [4].

4. **Application of BIM technology in an assembly-type vacation community project**

This resort project is located in the coastal area of Huidong County, Huizhou City, with a total construction area of 320,000 square meters, consisting of 28 multi-storey buildings, 13 high-rise buildings and a water sports center of nearly 20,000 square meters. The project became a pilot project combining prefabricated construction with BIM technology.

4.1. **Application of BIM technology in the design stage**

The clients of the project are mainly people on vacation, who do not have a high personalized demand for the house type, so the project has carried on the standardized design of the house from the design, and tried to reduce the room type. This architectural feature is very conducive to the industrial production of the project.

In the design stage, a three-dimensional visual model was established with the help of Revit software to design and adjust the functions and facades of the house in advance. Then, Navisworks
Manage integrated analysis software was used to integrate three-dimensional models of different specialties, such as architecture, structure, electromechanical, etc., into the same model. Each professional can exchange cross-professional information, and in the process of collaborative modeling, the professional model can be checked for several times to ensure its uniqueness and accuracy. Comprehensive crash testing of models can detect design errors in advance.

4.2. Application of BIM technology in component design
BIM component library is a standardized "series" library that contains all kinds of ready-made components (beams, panels, columns, doors, Windows, air ducts, power supplies, etc.). This library is created using BIM software and is a parameterized unit of BIM model. Various professional modelers can directly select or edit component information (shape, size, design parameters, etc.) from the component library, improving the efficiency of BIM modeling. In the manufacturing process of prefabricated components, the data of BIM model components are used to code each component, and the RFID (Radio Frequency Identification) tag chip is embedded into the component to facilitate the construction.

4.3. Application of BIM technology in construction organization
The construction area of the community is relatively large, and the overall construction time is longer. In order to achieve "partial completion and partial delivery", the construction is carried out in accordance with the principle of "municipal engineering priority". The septic tank, underground pipe network, permanent road, green belt and nearby buildings are constructed simultaneously to save as much time as possible. Before construction, BIM technology is used to simulate the construction of the site management mode. It is estimated that changing the traditional construction sequence will save the construction period of 6.5 months and save more than 3 million Yuan.

4.4. Application of BIM technology in construction technical guidance
Based on BIM model, construction simulation can be carried out. For the construction technology that is difficult for workers to understand, such as the assembly sequence of components, the position of steel bars, and the relationship between on-site pouring nodes, BIM technology is used to make complex node description and demonstrate to workers. Making the workers know the installation process of each component can better control the assembly of on-site components and improve the quality of installation of components.

In addition, BIM technology is also used in site layout, cost accounting and other aspects [5].

5. Conclusion
BIM technology can be applied to the management of the whole construction cycle of a building, and it is a powerful technical support means for the development of prefabricated buildings. It is the development direction of industrial construction production to establish the project construction management mode of "BIM+ assembly building".

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