

The Analysis of BIM Technology Applied in Prefabricated Buildings

Qianyi Jiang^{1, *, †}, Jingyi Wang^{2, †}, Chenxin Zhang^{3, †}, Yijia Zhao^{4, †}

¹College of Civil and Transportation Engineering, Shenzhen University, Shenzhen, China

²College of Information management, Nanjing Agricultural University, Nanjing, China

³School of International Education, Yunnan Agriculture University, Kunming, China

⁴School of Transportation Science and Engineering, Beihang University, Beijing, China

*Corresponding author: zhaoyijia@buaa.edu.cn

†These authors contributed equally.

Abstract. BIM technology is commonly applied in the prevalent trend of prefabricated buildings. The whole process of prefabricated building engineering may involve many units participating in it, which makes the process complex. This paper references and summarizes the BIM technology, with high efficiency in management and accuracy in simulation, and its software used in the prefabricated building engineering to simplify the project and make an illustration the whole life cycle. Meanwhile, the application of BIM technology in each process of prefabricated building engineering is also introduced in detail. The features of visualization and parameterization can help the participants work with better collaboration; simulation and coordination make the whole process become closely connected as well. This paper concludes with a summary of the characteristics of BIM technology, revealing that the predominance of BIM is inevitable in prefabricated building engineering.

Keywords: BIM, Prefabricated Building, NAVISWORKS, Whole Life Cycle.

1. Introduction

According to the current development needs of modern buildings, prefabricated buildings meet market demands, are green and environmentally friendly, and save time. Therefore, the development of prefabricated buildings is an inevitable trend for the development of the construction industry. Under the background of today's big data, the construction industry still has problems such as high construction energy consumption, shortage of building resources, and greater damage to the ecological environment. The modern construction industry has higher requirements for on-site management methods [1]. At present, the promotion of BIM technology in the field of prefabricated buildings is an important means to realize the streamlined design of prefabricated buildings and intelligent construction of 3D model construction, which can realize the integration of various stages of construction at a higher level [2].

Although some scholars have done preliminary research on the application of BIM technology in the construction stage of prefabricated buildings, most of them focus on the construction control of BIM technology and the integration of RFID material supervision information.[2] BIM technology is a data model that uses three-dimensional digital technology to connect different stages of construction projects [3]. BIM technology has a unique project data source, which can not only effectively solve the problem of global sharing and consistency in heterogeneous projects, but also realize the information management, creation and sharing of dynamic projects in the whole construction cycle of construction projects [4]. The prefabricated building is different from the traditional cast-in-place reinforced concrete building. Its components can be prefabricated directly in the factory. After the components are fabricated, they are transported to the site for hoisting and splicing. The integration of building decoration can not only carry out the main stage and the decoration stage simultaneously, but also make the design process more standardized and the components more standard, and at the same time, it can improve production efficiency and reduce construction costs [5].

Prefabricated buildings have the characteristics of green environmental protection, low construction cost, fast construction progress, and few hidden dangers in construction safety, and have the characteristics of complex construction data management. The use of BIM technology in the whole life cycle of prefabricated buildings can take advantage of the time-saving and labor-saving advantages of prefabricated buildings, while improving the efficiency of workers and the refinement of parts [6]. This paper analyzes the application and characteristics of BIM in different construction stages of the whole life cycle of prefabricated buildings.

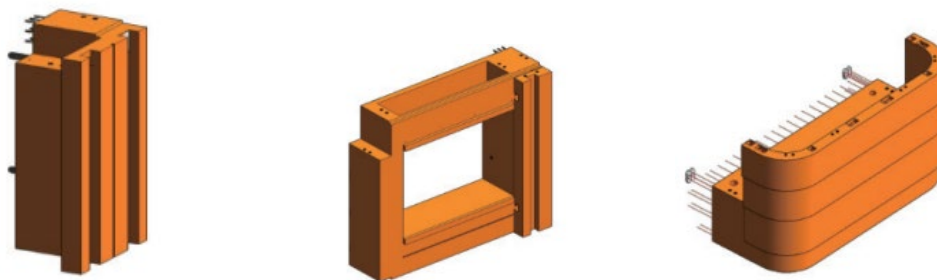
2. The technological process of the application

2.1 Designing process

BIM shares the ability to gather a large amount of information and details of the whole construction, for instance, PLANBAR which is one of the BIM software shares the function to design the module of the components. As a result, better statistic management could be achieved than before. In a word, BIM applies Simulation Optimization technologies to the prefabricated construction during the designing process.

2.1.1 Standard modeling and design

Under the premise of naming rules, information like PC component type and geometry could be set according to the project. Based on the information set, the designers could draw components, and establish house type and standard layer BIM models. Consequently, the professional design of architecture, structure electromechanical, and decoration could be exhibited. The assembly of the model could synchronously optimize each specialty through the automatic collision detection function. As a system, the PLANBAR model is carried out according to the principle of PC component splitting. The standardized design could be reduced to component size specifications such as the original column mesh from 7000-12000mm irregular sizes are optimized to three standardized sizes.



(a) Prefabricated decoration wall panel (b) Prefabricated exterior (c) Prefabricated balcony
Figure 1. The parametric family model of some prefabricated components

2.1.2 Precise inspection

Professional collision inspection could be carried out with regard to the majors. The inspection report which is generated automatically shows the source, position, and the number of collisions between the members. As a result, about 584 points of impact could be found during the inspection between the pre-embedded parts and the steel bar. Based on these conditions, the designers could analyze the causes of conflict comprehensively, optimize the design scheme, and improve the design in an all-round way. According to the feedback collision detection results, the designers could adjust and modify the component settings. The actual construction accessories production drawings are related to the construction accessories in the model through the underlying data information of BIM. Once it is corrected, the virtual component accessories in the model are modified, and the data information is transmitted in time through the BIM management platform. As a result, the corresponding component drawings are automatically updated in real-time. Precise control is a

traditional problem in assembling buildings nowadays. Through the assistance of BIM technology, accurate control of the component production could be improved.

2.2 Factory process

Assembling is the only thing the workers need to do during the factory process. However, it is also the most difficult part of the whole construction. Accuracy and professional coordination with construction is a major problem in the process. With the assistance of the BIM technologies such as REVIT and HIBIM, dynamic control could be realized in the whole process. For instance, the 3D modeling accuracy and scalability of REVIT provide a more realistic visual effect for later model reuse and avoid repeated modeling effectively. HIBIM runs through the whole life cycle of the project. BIM technology connects design, construction, cost, and consulting well to each other. As a result, the efficiency of processing components in the assembling buildings could be improved significantly.

2.2.1 Advanced coordination

Coordination with the construction is a difficult task in the traditional assembling buildings. The workers should determine the connection model of the prefabricated components reasonably according to the requirements of construction specifications. Meanwhile, there is a high level of engineering stability and construction safety in assembly building constructions. When it comes to the layout management, the appropriate construction machinery could be selected with regard to the requirements of the construction site and the workload. As a result, the demolition of the temporary facilities in the later construction could be reduced and the construction costs could be saved. In the project, secondary masonry would be simulated to facilitate construction personnel to help the workers be familiar with the relevant construction environment and calculate the scaffolding, secondary masonry, and temporary facilities. In terms of construction quality management, the problems could be classified, summarized, and archived through BIM technology. In the construction project, the problems would be anticipated before the construction. In a word, BIM technology improves the efficiency of quality management in prefabricated constructions.

2.2.2 Improved cost management

Before the construction of the project, it is automatically calculated according to the BIM model. Meanwhile, the cost budget is formed. It provides a reference basis for cost management in the actual construction process. The calculated budget is obtained after the model is optimized. The whole process has improved the accuracy of the budget. The model-related inventory information could be matched by means of the visualization function of the BIM technology which could support quantity, price, and indicator analysis. As a result, the material waste could be eliminated and the construction would be reduced during the construction of the assembling building. For example, there is a project about an assemble buildings of Guangxi Jiangtong Company. The construction makes full use of BIM technology to control the cost of site layout, safety management, materials, and technology. The specific work is shown in Figure 2.

There are also some drawbacks of cost management. Although BIM has many functions, it occupies a large amount of storage space at the same time. The amount of data generated in the construction stage alone could reach more than a dozen or even hundreds of bytes which also creates certain requirements for the selection and use of computers. It means the designers should choose high-configuration and high-performance computers. As a result, more money should be paid for the equipment.

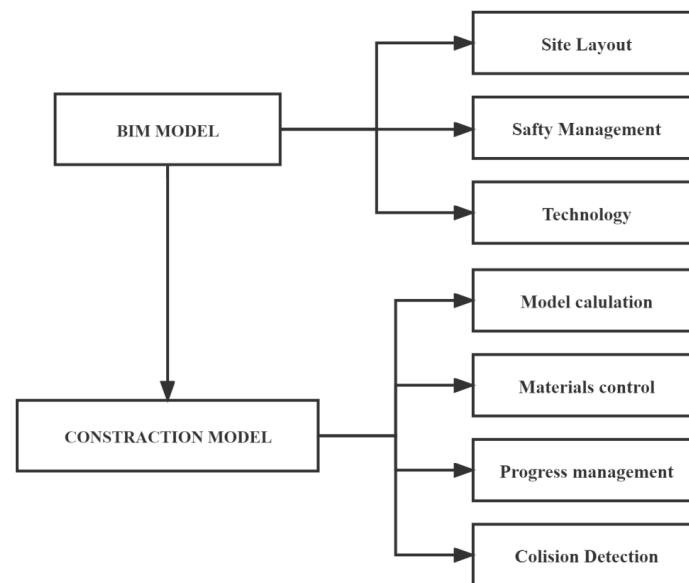


Figure 2. The specific work

2.3 Installation process

BIM site layout software could be adopted to place prefabricated components according to the tower lifting capacity in the assembling buildings. For instance, NAVISWORKS serves as the collision detection software in BIM. By means of NAVISWORKS, the designers would be able to integrate the efficient and excellent collisions of detailed structures and complex nodes. Consequently, the problem of the collision could be relieved.

2.3.1 Intuitive and three-dimensional

The construction unit needs to convert the two-dimensional drawings delivered by the design institute into three dimensions. The architectural, structural, and pipeline models are integrated to eliminate the design defects. The component model in the information database could be compared with the actual model in the process. The typical information could be ensured within the range of errors during the installation process of the assembling buildings. Meanwhile, the progress, cost, quality and safety information in the process is attached to the three-dimensional BIM model to form a multi-dimensional BIM model. In a word, the construction management could view all relevant information anytime and anywhere through the BIM model built. As a result, the installation process could be more intuitive than the traditional design.

2.3.2 Synergy and integration

In traditional installation construction, the unit involves multiple parties participating in the process. Especially in the construction of assembly buildings, more than two sites are involved to increase the application of structural accessories. It is more difficult for information coordination. However, with the assistance of BIM technology such as NAVISWORKS, the factory could be able to calculate the progress of the proposed project. If there is any problem, the plan could be revised at any time through the 3D simulation. At the same time, the schedule which supports multi-scheme comparison could be optimized. In a word, BIM technology ensures the synergy and integration in the installation process of assembling buildings. The process of installation in assembling buildings can be seen in Figure 3.



Figure 3. The process of installation in assembling construction

3. The main characteristics of the application

According to the current growth and development of the construction industry and the promotion of policies, BIM technology has greatly improved the informatization process of China's construction industry. According to the overview of BIM above and the engineering examples, the following characteristics of BIM technology are summarized.

3.1 Visualization of BIM Technology at Different Stages

BIM building information model is a 3D visualization model. Firstly, it can realize the transformation from a two-dimensional plane model drawn by traditional software to a three-dimensional solid model. Secondly, visualization is reflected in different stages of engineering projects, including engineering decision-making, design, construction, and later operation process. Participants at different stages can not only have a clearer and specific understanding of the engineering project process at this stage through BIM technology but also effectively promote communication among participants at different stages to reduce rework and other problems caused by construction errors.

3.2 Coordination between BIM technology platforms

BIM technology can create an information exchange platform, so that decision-makers can communicate effectively, meet the needs of different professions, and improve the quality and efficiency of design and construction.

3.3 Simulation of BIM technology in realistic scenes

Some supporting software of BIM technology can be applied on the actual construction site, through the combination of on-site BIM model and virtual hazard, so that designers and engineers can walk into the real virtual reality scene, and through immersive experience, engineers can get a more profound education of safety meaning and improve the production safety awareness level of all staff.

3.4 Integration performance of BIM technology

BIM technology has a trend of positive integrated design development, and it can play a role in the complete cycle process of decision-making, construction, operation and maintenance, through which, the construction efficiency is improved greatly, the construction period is shortened and the cost is reduced.

3.5 Parameterization of BIM technology

Parameterization is one of the major features of BIM technology. The advantage is that modelers can quickly and clearly become aware of the problems of the model, and have a deeper grasp of the overall structure of the model, which is conducive to the optimization of the scheme.

3.6 Scheme optimization

The whole process including design, construction, and operation, is a continuous optimization process. is a continual optimization process. There is no direct correlation between optimization and BIM, but BIM may help with better optimization. Three factors limit optimization: information, complexity, and time. There can be no decent optimization outcome without reliable data. The BIM model includes the building's real information, such as geometric information, physical information, rule information, and the building's actual existence after the alteration. The level of complexity is so great that participants will be unable to grasp all the knowledge on their own and will need the assistance of science, technology, and equipment. The intricacy of contemporary structures is often beyond the ability of those concerned. Complex projects may be optimized using BIM and its accompanying optimization technologies. The following are some of the things that current BIM-based optimizations can do:

i. Project scheme optimization

The impact of design modifications on ROI may be determined in real-time by merging project design with ROI analysis. In this way, the owner's design scheme selection will be based less on the shape evaluation and more on determining which project design scheme is best suited to their demands.

ii. Design optimization for special projects

Special-shaped designs may be seen everywhere, including the podium, curtain wall, and roof. These components make up a tiny percentage of the total building, but they account for a considerably higher proportion of the investment and labour, and they are typically the construction of the more challenging and time-consuming challenges. The optimization of these items' design and construction schemes can save a lot of time and money.

3.7 Drawing generation

BIM is not to produce the architectural design drawings issued by the architectural design institute that we often see in daily life, but through the visual display, coordination, simulation, optimization of the building, it can help the owner to produce the following drawings: Comprehensive pipeline diagram (after collision inspection and design modification to eliminate corresponding errors); Comprehensive structure hole drawing (embedded casing drawing); Collision check debug report and recommend improvement options.

4. Conclusions

In summary, it is commonly witnessed that BIM technology, which has shown great advantages in both visualization modeling and information integration, is widely used in prefabricated buildings. This paper especially focuses on the processes of designing as well as assembling of prefabricated building construction management. At the stage of designing, the PLANBAR system in BIM functions better in statistic management and can carry out professional collision inspection. The REVIT guarantees the accuracy and scalability of the 3D model, while HIBIM runs through the whole life cycle of the project, assuring its reliability. This paper makes a brief introduction to NAVISWORKS software, which stands an important role in avoiding collision by simulating and bringing out an animation to demonstrate. The technical features of BIM technology are also discussed above, including visualization, coordination, simulation, parameterization, optimization, and generation. During the designing and assembling stages, BIM can integrate multi-party elements and coordinate either comments or requests from participants, then build a 3D model by visualization

with high efficiency. It is also necessary for engineers to simulate the performance of components in different or even hazardous weather with BIM technology. After spotting the problems of the model built in the former stage by parameterization engineers then can optimize the construction management scheme in the following stages. For now, BIM technology is therefore widely used in engineering to improve efficiency and accord to the requirement of different units. BIM, with the features discussed above, is becoming an inevitable trend in prefabricated building engineering and will promote the processes in a greener way.

References

- [1] Zhang Ailin, Zhang Xiuying, Li Lu, et al. Application research of information integration dynamic management system in the construction stage of prefabricated buildings based on BIM technology [J]. *Manufacturing Automation*, 2017(10):5.
- [2] Sha Fengfeng. Application of BIM technology in prefabricated buildings [D]. East China Jiaotong University, 2021.
- [3] Tang Jihua. Research on BIM-based prefabricated building construction management system [J]. *Heilongjiang Science*, 2022, 13(6):3.
- [4] Yang Yingzi. Application of BIM technology in prefabricated building construction [J]. *Industry and Technology Forum*, 2022, 21(04): 58-59.
- [5] Gong Xun. The whole process management of prefabricated buildings and the application of BIM technology [J]. *Intelligent Building and Smart City*, 2022(03): 177-179.
- [6] Zhang Siyu. Analysis of Integrated Application of BIM Technology in Prefabricated Buildings [J]. *China Residential Facilities*, 2021(07): 97-98.
- [7] Yang Zhaoxu. Research on cost control of prefabricated building construction based on BIM [D]. North China Electric Power University, 2021.
- [8] Li Fenhong. Research on the application of BIM technology in the whole life cycle of buildings [J]. *Journal of Jiamusi Vocational College*, 2022, 38(03): 137-139.
- [9] Han Long. Research on the Application of Construction Cost Control Based on BIM Technology [D]. Hebei University of Geosciences, 2022.
- [10] Hu Xiaoling, Lai Jingting, Nong Ridong. Research on the design deepening and cost management application of prefabricated buildings based on BIM technology [J]. *Guangxi Urban Construction*, 2021, (12): 108-112.
- [11] Yang Qian, Li Juan, Fan Linlin, Fang Qi. Research on the Construction of Building Intelligent Operation and Maintenance Management System Based on BIM Technology and New Information Technology [J]. *Sichuan Architecture*, 2022, 42(01): 210-211.
- [12] Ni Qing. Application of Navisworks software in project construction simulation [J]. *Anhui. Architecture*, 2020, 27(02): 184-186.
- [13] Hu Youbin, Xu Anfei. Research on efficient design of PC components based on PLANBAR and in-depth application of BIM achievements [C]. *Proceedings of the 2021 Industrial Architecture Academic Exchange Conference (Volume 2)*. 2021:1002-1007+1001.
- [14] Wang Shuqiang, Peng Saiqing, Lu Zhongxing. Research on the integration and application of PC component design and production information based on BIM [J]. *Construction Economy*, 2020, 41(05): 109-114.
- [15] Li Xinsheng, Zheng Qizhen, Wu Lufang, Lu Tao, Chen Gang. Research on the application of BIM combined with material coding in the management of prefabricated building materials [J]. *Building Construction*, 2021, 43(10):2209-2213.
- [16] Li Xinsheng, Zheng Qizhen, Wu Lufang, Lu Tao, Chen Gang. Research on the application of BIM combined with material coding in the management of prefabricated building materials [J]. *Building Construction*, 2021, 43(10):2209-2213.
- [17] Su Yangang. Exploring the application of BIM technology in the construction of prefabricated buildings [J]. *Journal of Chifeng University (Natural Science Edition)*, 2022, 38(02): 28-31.