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Application Strategy of BIM Technology in Virtual Construction of Prefabricated Buildings

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Abstract: In order to improve the construction efficiency, save resources, reduce costs, and to protect the environment during the construction work, prefabricated buildings is an important process that is needed to be carried out during the construction. However, in the current situation, lack of knowledge related the prefabricated buildings, and irrationalities of the relevant staff, limits the practical application of the prefabricated buildings. Simulating construction through building information modeling (BIM), can fully simulate various situations that may occur in the construction process, and also can improve the quality and efficiency of the prefabricated building construction work, therefore, this paper analyzes the application strategy of BIM technology in the virtual construction of prefabricated buildings as a reference.

Keywords: BIM technology; Prefabricated buildings; Virtual construction

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1. Introduction

In recent years, China has undergone many social developments, especially in the application of computer technology, which further can promote the development of many industries. BIM technology, has been rapidly applied in the construction industry, by integrating various disciplines that are involved in the construction industry into a package, which can improve the traditional construction mode. Additionally, the application of BIM technology in the prefabricated buildings, may reflect high application value in many aspects such as design, component production, and construction management, therefore, the application of BIM technology in the construction of prefabricated buildings is conducive to promote the development of prefabricated buildings. Further, the application of BIM technology in virtual construction work, can help to simulate the construction process by building a three-dimensional model, improving the construction quality and efficiency, and further effectively reduce the project cost, risks, and also may shorten the construction duration. Therefore, it is important to investigate the application strategy of BIM technology in the virtual construction of prefabricated buildings.

2. Prefabricated building

2.1. Features of prefabricated buildings

The prefabricated building is based on the industrialization. Therefore, it is important to standardized a construction design before starting the construction work, followed by integration of the building decoration in the construction work according to the actual situation, and finally, continue with information management work. Compared with the traditional buildings, prefabricated buildings have few main features,

which are described as below [1].
(1) Environmental protection: the prefabricated parts used in the prefabricated buildings are mainly factory-produced, and only brought to the construction site to be installed, with less involvement of the wet operations, thereby less production of construction waste.
(2) Energy saving: the prefabricated wall contains an insulating layer, which can help to control the temperature in winter and summer, thereby reducing energy consumption.
(3) Shortening the construction period: reduce in the wet operation in the construction side, can further reduce the overall construction duration.
(4) Reduce labor costs: the prefabricated construction is mainly automated, thereby reducing the number of the construction personnel, further may improve the construction efficiency, and reduce labor costs.
(5) Safety assurance: the on-site construction operating environment can be fully improved, which can effectively reduce the probability of casualties.

2.2. Prefabricated building construction process

The construction process of prefabricated buildings can be divided into 12 steps as described below.
(1) Prefabricated parts transportation: according to on-site construction requirements, prefabricated parts are produced in the factory, then transported to the construction site at a reasonable speed, and placed in a specific position, followed by hoisting work by tower crane.
(2) Install the external wall: perform hoisting work of the external wall panel by using appropriate support according to the design drawings.
(3) Wall panel firmware installation: install the wall panel firmware with a board seam with the width of 20-25mm, according to the relevant requirements.
(4) Installation of superimposed beams: complete the hoisting work of superimposed beams by using a clamp.
(5) Install the inner wall panel: perform hoisting work of the inner wall by using wall panel, according to the design drawings. During the hoisting process, it is important to cross-check whether the installation of the front and back is correct, in order to obtain a reasonable support.
(6) Concrete pouring: the surface of the prefabricated member is properly treated, followed by concrete pouring in the form of layered.
(7) Removal of formwork and support: remove the formwork and diagonal support after the strength of the concrete is achieved to certain level.
(8) Laminated plate support: placed the laminated plate support to ensure the good stability of the laminated board [2].
(9) Install the laminated board: install the laminated board one by one according to the number, and the design drawings [3].
(10) Install the stairs
(11) Pre-embedded
(12) Concrete pouring, tamping work, and calendaring work for the floor [4].

3. Case study

3.1. Project Overview

Taking a public rental housing project as an example, BIM technology is used to perform the virtual construction in prefabricated buildings. The construction area of the project is about 93,637 m^2, with Building 2 having an area of 14,750 m^2, Buildings 3 and 6 have an area of 14,750 m^2 respectively, and the floor area is around 7,341 m^2. There are a total of 21 floors, with 18 floors above the ground, 2 floors of underground storage rooms, and 1 floor for underground garage. The residential building is designed using a shear wall structure, meanwhile, the public building and the garage is designed based on the frame structure of cast-in-place concrete. The underground structure, the first and second floors above the ground is designed based on the concrete shear wall structures. The 3rd to 18th floors above ground, are designed based on the prefabricated structures, and the overall prefabricated assembly rate is about 85%.

3.2. Application of BIM technology in virtual construction

The application of BIM technology in the virtual construction process is shown in **Figure 1**.

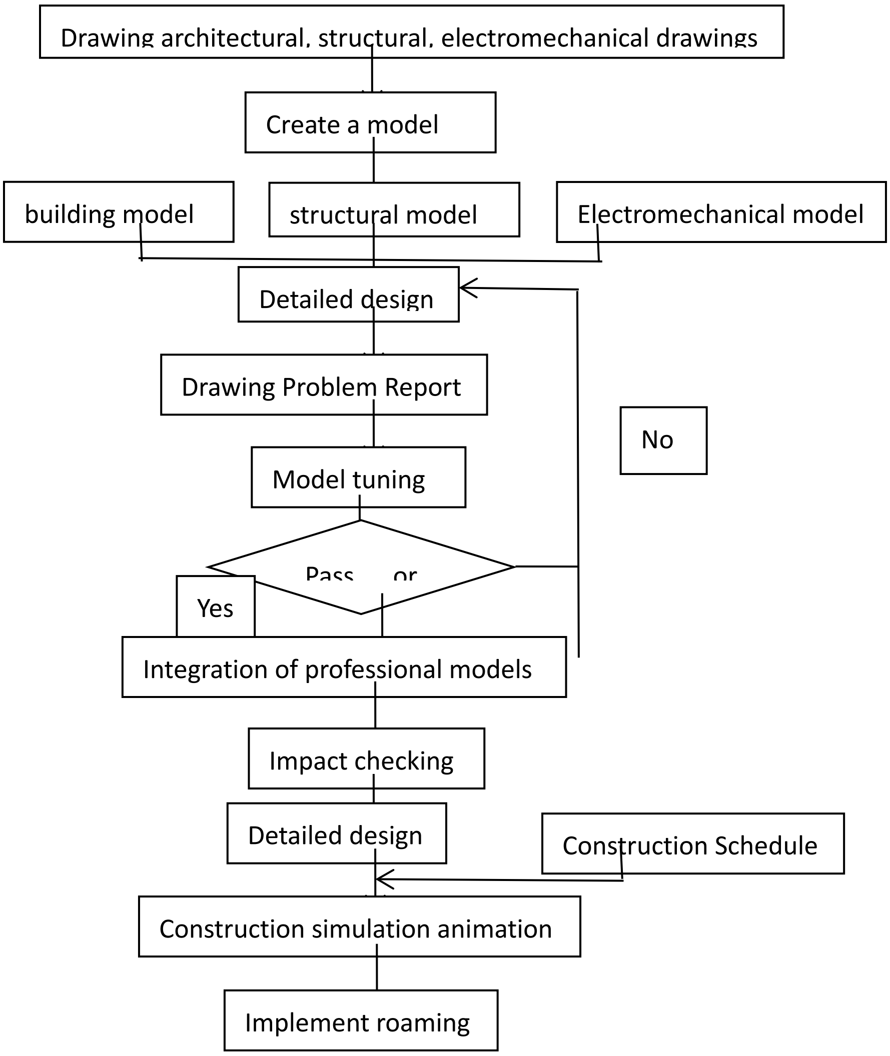

Figure 1. Application process of BIM technology

3.3. Construction process simulation

3.3.1. Drawing CAD drawings

The BIM software, Revit was used for the construction process simulation, and the usage of the plug-in with it effects are shown in **Table 1**.

Table 1. Comparison of CAD drawings with plug-ins

Use plugins	Create group	Entity	Human error	Time	Accuracy	The cost
Yes	no need	no need	No	0.5—1h	Good	1200 yuan/year
No	great amount	All	Yes	About 4h	Generally	0 yuan

According to the Table 1, the usage of plug-in in the process of CAD drawings, may have many advantages such as (1) Rapid modeling: by applying the plug-in in this project, the modeling time can shorten up to 70% [5], (2) Reduce costs: the application of plug-ins can improve the quality and efficiency of the work, greatly shortened the modeling duration with higher in accuracy, leads to cost reductions [6], (3) Improve the accuracy of modeling: the model can be directly generated, therefore, it does not need secondary processing [7,8], which may cause information loss, or human error, (4) Format conversion: information in component space attributes can be transfered into a three-dimensional state or model, therefore, the spatial attributes of the components can be fully displayed, further improve the accuracy of the drawings [9].

3.3.2. Assembly stage

To create a model of a prefabricated building, it is important to create a component model, to ensure that it has various attributes of the real components [10], therefore, it can be used as a basis or references for analysis during construction work. From a practical point of view, components such as prefabricated beams, laminated panels, and external wall panels occupy an important position in the construction of prefabricated buildings, therefore, during virtual construction, attention should also be given to the three-dimensional display of its component models [11] as shown in **Figure 2**.

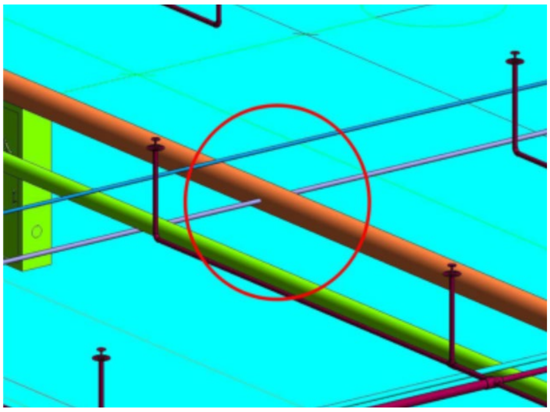

Figure 2. Partial 3D display of component model

3.3.3. Drawing review

If a drawing provided by the designer, did not have high precision, it will cause a difficulty to fully match the actual construction situation on the site, additionally, it also impossible to use drawings to guide on-site construction, especially for the construction of the mechanical and electrical facilities, which has a high degree of complexity. Therefore, it is important to design the drawing of the construction site, with the help of BIM models, because the application of BIM models enables the visual analysis of the buildings. After the model is created, the content of the drawings, and the model can be compared, to further improve the construction work [12]. For example, when a model is created according to the drawing content, if there is any pipeline collision, the model, and the drawing can be modified and updated on at same time as shown in **Figure 2**. By improving the models and the drawing, it can further help to improve the quality and efficiency of construction work on the side [13].

3.3.4. Construction progress simulation

The simulation of the construction progress of the prefabricated building project is conducive, to further optimizing the construction plan, and to provide more comprehensive guidance for the on-site construction. In this project, the construction progress stimulation was performed using Navisworks software, which has lower application cost, and lower requirements for computer hardware [14]. There two important aspects involved in the stimulation process as described below.

(1) Preparation of construction progress

Before conducting the construction simulation work, two aspects of information, namely the three-dimensional model, and the construction schedule was prepared. Next, the simulation work is carried out by importing the BIM model, and the construction schedule into the Navisworks. At the same time, the construction schedule is prepared using Microsoft Project [15].

(2) Progress simulation

After the model creation, and the construction schedule preparation is completed, the dynamic demonstration of the construction process is carried out by using the model and the content of the plan. In order to clearly, accurately, and intuitively communicate the construction instruction, the construction schedule is converted into a task list, through rebuilding the task hierarchy [16]. Additionally, different lights, and building materials are adjusted to view the construction effect under different light sources and materials in the real time [17].

During the construction process, the difference in time periods, construction types, and components used, may lead to be re-construction, demolishment or temporarily stopped of the construction process. Therefore, it is necessary to reasonably classify various operations with the help of the task type project, to ensure that the building appearance is in a reasonable state during different time periods, and all the components is correctly applied [18].

Additionally, during the simulation process, the construction date, stage, and area can be displayed in real time, allowing a comprehensive comparison between the models, and the actual construction situation, and also may provide information on the actual construction progression. Further, during virtual construction, if there is any possibility of arising any bad situation, it should be solved in time. It enables the overall virtual construction to be continuously optimized, which also can promote the improvement of the actual construction quality, save construction costs, and shortening the construction period [19].

However, the virtual construction process also has certain shortcomings. For example, all the models are displayed in the same picture, which may interfere with the display or image clarity. Additionally, the animation display can easily lead to partial occlusion of the model, therefore, it is impossible to fully view the correlation between the construction process, space and time [20].

4. Conclusion

With the rapid development of contemporary in China’s construction industry, the application scope of prefabricated buildings is getting wider. Applying BIM technology to carry out virtual construction is conducive, to optimizing construction design, reducing the construction costs, and also shortening the construction period, leading to the improvement of construction quality, efficiency and the safety, and also effectively guarantee the practicability of the prefabricated building.

Disclosure statement

The authors declare no conflict of interest.

References

[1] Ke L, Qingwei G, 2021, Research on Virtual Construction of Steel Structure Prefabricated Buildings Based on BIM Technology. Sichuan Building Materials, 47(9): 109-110. http://org.10.3969/j.issn.1672-4011.2021 .09.054

[2] Zhiming H, Bo S, Xintian Y, et a., 2020, Application Analysis of PKPM-PC in Design of Prefabricated Concrete Structures. Urban Architecture, 17(29): 99-100.

[3] Zheng Z, Langni D, Ling L, et al., 2020, Research on the Construction Method of Knowledge Map of Hotspots in the Application of BIM Technology in the Detailed Design and Construction of Steel Structures. Information Technology of Civil and Construction Engineering, 2020(3): 16-21.

[4] Linlin X, Yajiao C, 2020, Research on Intelligent Management Platform for Prefabricated Building Project Scheduling Based on BIM + Digital Twin Technology. Construction Economy, 41(9): 44-48. http://.org.10.14181/j.cnki.1002 -851x.202009044

[5] Xiang F, Jinyang D, Liqi Y, 2021, Digital Research of BIM + Cloud Technology in the Whole Life Cycle of Prefabricated Buildings. Brick and Tile, 2021(5): 53-54. http://org.10.3969/j.issn. 1001-6945.2021.05.021

[6] Zheng Z, Langni D, Ling L, et al., 2020, Research on the Construction Method of Knowledge Map of Hotspots in the Application of BIM Technology in the Detailed Design and Construction of Steel Structures. Information Technology for Civil and Construction Engineering, 12(3): 16- 21. http://.org.10.16670/j.cnki.cn11-5823/tu.2020.03.03

[7] Rui L, 2020, Discussion on the Application of BIM Technology in the Quality Control Process of Prefabricated Building Construction. Architecture and Decoration, 2020(11): 92.

[8] Hongwei H, 2020, Application Analysis of BIM Technology in Safety Management of Prefabricated Buildings. Smart City, 6(11): 102-103.

[9] Ke L, Qingwei G, 2021, Research on Virtual Construction of Steel Structure Prefabricated Buildings Based on BIM Technology. Sichuan Building Materials, 47(9): 109-110, 113. http://org.10.3969/j.issn.1672-4011.2021 .09.054

[10] Xin X, 2021, The Application Value of BIM Technology in the Construction of Prefabricated Buildings. Smart City, 7(24): 157-158.

[11] Yuanchang M, 2021, Research on the Application of BIM Technology in the Construction Process of Prefabricated Buildings. Intelligent Building and Construction Machinery, 3(4): 24-26.

[12] Weiping W, Chengcheng W, 2021, The Application of BIM Technology in the Construction of Prefabricated Buildings. China New Technology and New Products, 2021(5): 98-100. http://org.10.3969/j.issn.1673-9957.2021.05.032

[13] Haoze L, Sulei L, Zhenying L, 2018, Discussion on the Application of BIM Technology in Quality Management of Prefabricated Building Construction. Doors and Windows, 2018(12): 236-237.

[14] Wentong B, 2021, Application of BIM Technology in Prefabricated Buildings. Bricks and Tiles, 2021(8): 70-71. http://org.10.3969/j.issn.1001-6945.2021.08.027.

[15] Liusuo D, Xintong M, Zhihui H, et al., 2020, Application of BIM Technology in Construction Management of Large-Scale Prefabricated Buildings in Tianjin Jintangyuan. Architectural Technology, 51(11): 1301-1304.

[16] Zhanfang H, Xiaoqing Z, Yintai S, et al., 2020, Application Of VR+BIM Technology in Prefabricated Buildings. New Materials and New Decoration, 2(18): 34-35. http://10.12203/j.xclxzs .1671-9344.202018021
[17] Dongdi Q, 2021, Analysis of Hoisting Construction of Prefabricated Buildings Based on BIM Technology. Architecture and Decoration, 2021(29): 191-194.
[18] Zengping H, 2020, BIM Virtual Installation and Construction Technology of Prefabricated Buildings. Fujian Construction Technology, 2020(1): 99-101,108.
[19] Zhixin L, 2021, High-Precision Control of Building Assembly Process Based on BIM Technology. Information System Engineering, 2021(9): 25-27. http://org.10.3969/j.issn.1001-2362.2021.09.010
[20] Linlin X, Yajiao C, 2020, Research on Intelligent Management Platform for Prefabricated Building Project Scheduling Based on BIM + Digital Twin Technology. Construction Economy, 41(9): 44-48. http://10.14181/j.cnki.1002 -851x.202009044