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Research on the Integration of Ultra-low Energy Consumption and Low Carbon Buildings based on BIM and Assembly Technology

Lin Liu[1,2], Dongmei Wang[1,2], Qiaoyun Li[1,2], Zijun Zhao[1,2], and Hai He[1,2]

[1] China Building Technique Group Co.,Ltd., Beijing 100013, China

[2] China Academy of Building Research, Beijing 100013, China

Abstract

Under the guidance of the "double carbon" goal, the green, industrialization and informatization transformation of the construction industry has become an inevitable trend. With the characteristics of high efficiency, energy saving and environmental protection, combined with the advantages of digitization, coordination and visualization of BIM technology, prefabricated buildings provide a technical path for achieving ultra-low energy consumption and low carbon goals. This paper analyzes the application mechanism of BIM technology in the whole process of prefabricated building design, production, construction and operation and maintenance based on the B23 R&D design project of 1605-650 block in the north I area of Shijingshan Park, Zhongguancun Science and Technology Park, Shijingshan District, Beijing, and discusses its role in energy-saving design, carbon footprint control and resource optimization, so as to promote the deep transformation of the construction industry to ultra-low energy consumption and low carbon.

Keywords

Prefabricated Building; BIM; Ultra-low Energy Consumption; Low-carbon Buildings; Intelligent Construction.

1. Introduction

The construction industry is a key area of energy consumption and carbon emissions in China. The traditional construction mode has serious waste of resources and high pollution emissions, and it is difficult to adapt to the requirements of green development [1]. Prefabricated buildings significantly improve construction efficiency and reduce on-site operation pollution through component prefabrication and construction assembly, which is the key path to realize building industrialization. As the core carrier of building informatization, BIM technology provides technical support for the realization of refined design, intelligent construction and intelligent operation and maintenance of prefabricated buildings through three-dimensional modeling, data integration and whole-process collaboration. The deep integration of the two is an important guarantee to promote the realization of ultra-low energy consumption and low-carbon goals in buildings.

2. The Coordination Mechanism between BIM and Prefabricated Building

2.1. Coordination and Optimization in Design Stage

2.1.1. Sub-section Headings

This project adopts BIM technology in the design stage, through parametric modeling and multi-disciplinary collaboration, to realize the precise splitting and deepening design of prefabricated components. In the project, Revit is used to complete the three-dimensional

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modeling and automatic calculation of the water supply and drainage and HVAC system. The design cycle is shortened by 33 % [2,3], and the collision detection optimization is 4251, which significantly improves the design accuracy.

Figure 1. Parametric and modular design

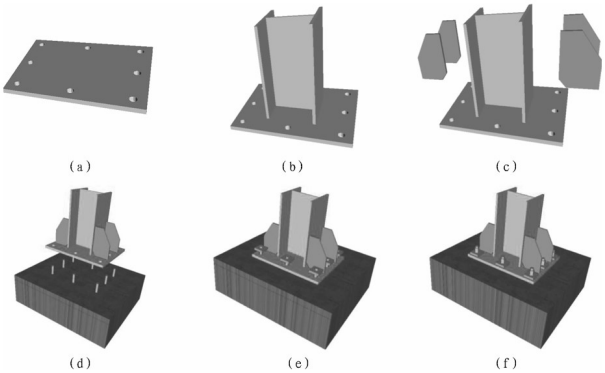

Figure 2. Accurate component splitting and deepening design

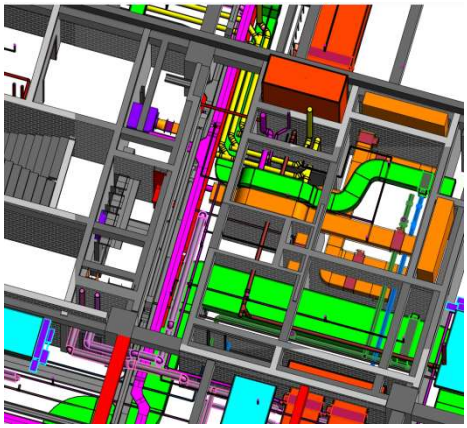

Figure 3. 'Virtual pre-assembly 'and collision detection

2.2. Intelligent Control of Production and Transportation.

The component information model based on BIM is combined with the Internet of things, RFID and other technologies to realize the whole process tracking from production, transportation to hoisting. A high assembly rate residential project realizes real-time monitoring of component status [4], improves scheduling efficiency and reduces transportation carbon emissions through the " one piece, one code " management platform.

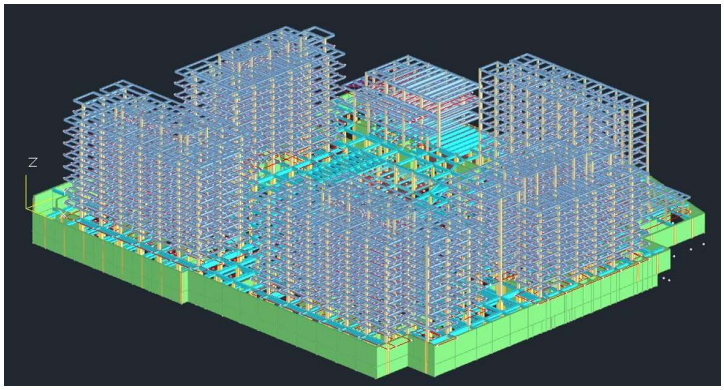

Figure 4. Real-time monitoring of component status

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2.3. Digital Management in Construction Stage.

BIM is combined with 4D / 5D models to support dynamic management of schedule, resources and costs. Construction simulation and collision detection through Navisworks to avoid rework ; combined with Dynamo script to optimize the pipeline layout, the prefabrication rate is increased to more than 40 %, and the material waste rate is controlled within 2.1 % [5].

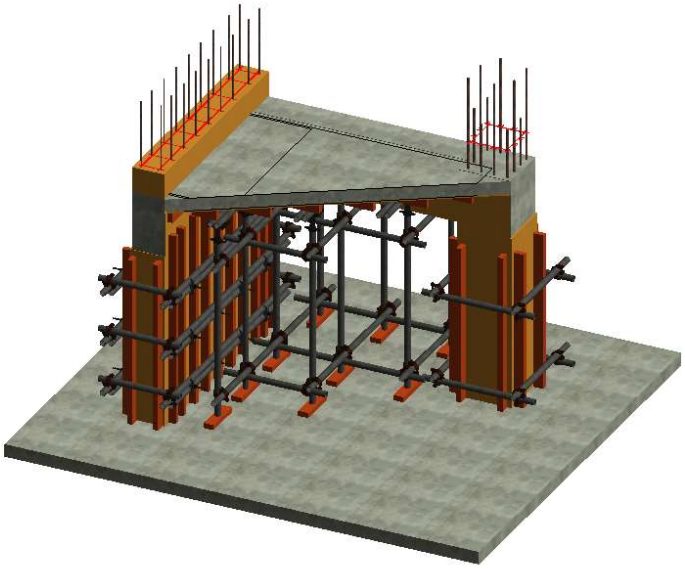

Figure 5. Construction simulation

3. Ultra-low Energy Consumption and Low-carbon Technology Path

3.1. Energy-saving Design and Energy Consumption Simulation.

BIM is combined with 4D / 5D models to support dynamic management of schedule, resources and costs. Construction simulation and collision detection through Navisworks to avoid rework ; combined with Dynamo script to optimize the pipeline layout, the prefabrication rate is increased to more than 40 %, and the material waste rate is controlled within 2.1 %.

3.2. Green Building Materials and Carbon Footprint Management.

Prefabricated buildings promote the use of green materials such as recycled concrete and lightweight high-strength building materials [6], combined with BIM model for carbon footprint calculation and material optimization. The inner partition wall of this project is arranged with ALC strips to reduce material loss and reduce carbon emissions by 20 % during construction.

3.3. Energy System and Intelligent Operation and Maintenance.

BIM is integrated with building automation system (BAS) to realize energy consumption monitoring, equipment management and fault warning. In prefabricated buildings [7], solar photovoltaic, rainwater recovery and other systems are integrated to build an energy self-sufficiency and resource circulation system to support the ultra-low energy consumption operation of buildings.

4. Development Suggestions and Prospects

4.1. Construction of Carbon Label and Standard System.

Promote the carbon labeling system of prefabricated buildings [8], establish a full life cycle carbon emission database, and promote the transparency and standardization of carbon data.

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4.2. Deepen the Integration of BIM and Low-carbon Technology.

Strengthen the integration of BIM with the Internet of Things, big data, AI and other technologies, and build a low-carbon management platform integrating ' design-construction-operation and maintenance '.

4.3. Promote Policy and Industry Collaboration.

Improve green building materials certification, carbon trading and financial support policies, promote collaborative innovation between industry [9], university and research, and build a green building industry ecology.

5. Conclusion

The deep integration of BIM technology and prefabricated buildings is not only an inevitable trend of technological innovation in the construction industry, but also a core path to achieve ultra-low energy consumption and low-carbon goals. In the future, we should further strengthen technology integration, standard construction and policy guidance, promote the comprehensive transformation of the construction industry to green, industrialization and intelligence, and provide solid support for the realization of the " double carbon " goal.

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