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Innovative Application of BIM Based Intelligent Prefabricated Buildings in Green and Low-carbon Design

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Abstract. This article explores the innovative application of intelligent prefabricated buildings based on BIM technology in green and low-carbon design. By analyzing the combination of BIM technology and prefabricated buildings throughout their entire life cycle of design, construction, and operation, the enormous potential of BIM technology in energy conservation, emission reduction, resource utilization efficiency improvement, and optimization of building performance has been demonstrated. Research has shown that BIM technology can effectively improve the design accuracy and construction efficiency of prefabricated buildings, reduce material waste and carbon emissions, and promote the sustainable development of the construction industry. In addition, this article also combines practical application examples to illustrate the specific application effects of BIM in intelligent prefabricated buildings, and looks forward to future development directions.

Keywords: BIM technology, intelligent prefabricated buildings, green and low-carbon design, energy conservation and emission reduction, sustainable development.

1. Introduction

In the context of increasingly serious global environmental problems, green and low-carbon design in the construction industry has become a key issue. Prefabricated buildings, as an important form of industrial development in construction, have the advantages of energy conservation, environmental protection, and high efficiency. The rapid development of BIM technology has provided strong technical support for this field. BIM not only optimizes building design and improves construction efficiency, but also enables precise energy management during the operation and maintenance phase, comprehensively promoting the green and low-carbon development of buildings. This study aims to explore the combination of BIM technology and intelligent prefabricated buildings, analyze their innovative applications and future development prospects in green and low-carbon design.

2. The Current Development Status of BIM Technology in Green and Low-carbon Design Of Prefabricated Buildings

In China, prefabricated buildings have received widespread attention and promotion due to their advantages such as energy efficiency, environmental protection, and fast construction. The introduction of BIM technology has brought revolutionary breakthroughs to the green and low-carbon design of prefabricated buildings. Currently, BIM technology has been preliminarily applied in prefabricated buildings, mainly reflected in optimizing design processes, improving resource utilization efficiency, and reducing construction waste. BIM technology enables designers to accurately simulate and evaluate the energy consumption of buildings in the initial stage through the precise construction of three-dimensional digital models. This data-driven design approach effectively avoids the problem of inaccurate energy demand forecasting in traditional designs, thereby significantly improving the energy utilization efficiency of buildings. In addition, BIM technology also supports multi-disciplinary collaborative work, closely connecting multiple aspects such as architectural design, structural design, and equipment design, thereby reducing design conflicts caused by information asymmetry and improving the rationality and sustainability of overall design.

The application of BIM technology in the construction phase of prefabricated buildings also provides strong support for green and low-carbon design. In the actual construction process, BIM technology can simulate the manufacturing, transportation, installation and other aspects of components in detail through precise virtual construction, thereby reducing material waste and construction energy consumption in traditional construction. Specifically, BIM can effectively reduce material waste rates and make prefabricated buildings more in line with green building standards through precise component scheduling and on-site management. In the maintenance and management phase, the application of BIM technology also demonstrates its advantages in green and low-carbon design. The BIM based building management platform can integrate data information from the entire life cycle of buildings, monitor key indicators such as building energy consumption and equipment operation in real time, and provide scientific basis for energy-saving measures in the operation and maintenance stage. Through intelligent monitoring and analysis, BIM can not only improve the energy management efficiency of buildings, but also provide data support for the green transformation and optimization of future buildings.

Although BIM technology has achieved certain results in the application of green and low-carbon design in prefabricated buildings, its widespread promotion still faces many challenges, such as inconsistent technical standards and compatibility issues between software tools. Therefore, further application of BIM technology in green and low-carbon design of prefabricated buildings in the future still requires joint efforts from all parties in the industry to promote technological improvement and innovation.

3. Technical Bottlenecks and Challenges Faced By Intelligent Modular Buildings in Green Design

Although the application of intelligent modular buildings in green and low-carbon design has shown great potential, there are still many technical bottlenecks and challenges in its actual promotion process. BIM technology, as the core support of intelligent prefabricated buildings, faces key obstacles in standardization and technical compatibility. Currently, there are differences in the tools and software used in different design and construction stages of BIM technology, leading to issues in data format, information transmission, and model collaboration. The lack of interoperability between different platforms hinders collaborative work among various disciplines and limits the comprehensive application of BIM technology in green design. At the same time, the construction process of intelligent modular buildings highly relies on precision industrial production systems, but in practical operations, there is still a significant gap between the accuracy of component processing and the controllability of construction. Although BIM technology can provide accurate construction simulation and scheduling arrangements, in actual implementation, prefabricated components are difficult to fully achieve design accuracy in production, transportation, and installation, resulting in reduced energy efficiency and material waste. This not only affects the achievement of green design goals, but also increases the construction cost and carbon emission burden of the project.

Another challenge lies in the real-time integration and dynamic updating of data in the full lifecycle management of buildings. Although BIM technology can provide data support throughout the entire lifecycle of a building, there are discontinuity issues in data collection, analysis, and feedback during the building's usage phase in practical applications. The limited integration of sensors and other intelligent devices with BIM platforms results in the inability to achieve expected energy management and optimization during the building operation and maintenance phase. This situation of information asymmetry limits the greater role of BIM in the operation and maintenance phase, affecting the overall green performance of intelligent prefabricated buildings. The green design concept of prefabricated buildings faces resistance from traditional building habits and industry inertia in the promotion process.

Many designers, construction companies, and maintenance personnel lack sufficient understanding and training on intelligent technology and its applications, which makes it difficult to fully utilize the true advantages of BIM technology in project implementation. Especially in the technical details of green and low-carbon design, the industry lacks unified norms and standards, making it difficult to ensure consistency among all parties in project design, construction, and operation. Therefore, intelligent prefabricated buildings not only need to solve technical bottlenecks in green design, but also need to promote the development of industry standardization and enhance the technical literacy of practitioners in order to truly achieve the low-carbon goals of green buildings.

4. Innovative Methods Based on BIM Technology to Enhance The Design Effect of Green and Low-carbon Buildings

The green and low-carbon building design based on BIM technology has shown great potential in innovative practices in the construction industry. In order to further enhance the design effectiveness of green and low-carbon buildings, BIM technology can achieve design optimization through various innovative methods. Its core lies in utilizing the advantages of digital technology to enhance the green sustainability of various stages of building design, construction, and operation. In the design phase, BIM technology can help designers comprehensively analyze the energy consumption of buildings by creating accurate 3D models. This model not only includes structural information of the building, but also integrates various energy consumption related data, such as the operating modes of lighting, ventilation, heating and other systems. Through this comprehensive analysis, designers can predict the energy consumption of buildings in different usage scenarios in advance and optimize design schemes to ensure maximum energy efficiency of the building. For example, BIM models can simulate the path of natural light and ventilation effects, thereby designing building facades and spatial layouts that are more in line with green and energy-saving standards.

The multidimensional integration capability of BIM technology also plays a crucial role in the selection and use of building materials. Through precise material analysis and usage planning, BIM can help design teams select materials with more environmentally friendly properties and reduce waste. Through virtual construction, designers can plan the cutting method and transportation path of materials in advance, ensuring more efficient use of materials. This precise planning not only reduces material waste in construction, but also significantly lowers the carbon emissions of buildings, providing strong support for achieving green design goals. During the construction phase, BIM technology can effectively improve the green benefits of the construction process through virtual simulation and digital management tools. By dynamically managing the entire construction process, BIM can adjust the construction progress in real time, avoiding duplicate construction and resource waste. By combining precise construction simulations, the construction party can anticipate potential construction conflicts in advance and make adjustments, thereby reducing construction waste and energy consumption. At the same time, BIM technology also supports intelligent management of resource scheduling on construction sites, minimizing resource idle and waste, and achieving green construction.

During the operation and maintenance phase, BIM technology can provide important basis for energy-saving management of buildings by integrating data from the entire lifecycle of the building. Based on BIM models, operation and maintenance personnel can monitor the energy usage of buildings in real time, identify abnormal energy consuming links, and make timely optimization and adjustments. In addition, BIM technology can also support the integration of smart devices, further improving the energy management efficiency of buildings. For example, by integrating sensor data, BIM platforms can help buildings achieve intelligent regulation of lighting, ventilation, heating, and other systems, ensuring that buildings can maintain efficient energy efficiency during use. The combination of these innovative methods has enabled BIM technology to play an important role in improving the design effectiveness of green and low-carbon buildings.

5. Application Examples of BIM Technology and Prefabricated Buildings in Green and Low-Carbon Design

The combination of BIM technology and prefabricated buildings has achieved significant results in green and low-carbon design, and the huge advantages of this technology have been demonstrated in many practical projects. In the process of architectural design, BIM technology helps design teams optimize the structure and functional layout of buildings through visualized 3D models, enabling buildings to maximize the use of natural resources and achieve energy-saving goals. For example, in some large public buildings, BIM technology is used to analyze the best design solutions for natural lighting and ventilation, thereby reducing the energy consumption of artificial lighting and mechanical ventilation systems. Through this precise design optimization, not only has the comfort of building use been improved, but energy consumption in daily operations has also been significantly reduced.

During the construction phase, the application of BIM technology further demonstrates its advantages in efficient resource utilization and energy conservation and emission reduction. As a part of industrial production, prefabricated buildings greatly reduce material waste and energy consumption during on-site construction through the standardization and precision of prefabricated components. Through the virtual simulation of the entire construction process using BIM technology, the construction party can effectively anticipate potential problems during construction and make corresponding adjustments. This digital management method ensures that each component of prefabricated buildings can be accurately connected, avoiding unnecessary material waste and repetitive construction. In addition, the progress management function of BIM technology enables the construction party to arrange manpower, material resources, and equipment reasonably, reducing resource idle and energy consumption increase during the construction process. BIM technology also provides strong support during the operation and maintenance phase of buildings. By integrating with sensors and monitoring devices, BIM models can monitor the energy usage of buildings in real-time, providing accurate data analysis and feedback. For example, some smart office buildings adopt BIM technology for energy management, which automatically adjusts the lighting, heating, and ventilation systems inside the building through data feedback in the model to ensure efficient use of energy. This precise adjustment not only greatly reduces operating costs, but also reduces unnecessary energy waste, further promoting the practical effect of green and low-carbon building design.

Some residential projects have also demonstrated the effective application of BIM technology and prefabricated buildings in green and low-carbon design. Through the comprehensive application of BIM technology, these residential projects can simulate and optimize future energy consumption and carbon emissions in the early stages of design, thereby achieving energy-saving goals in subsequent construction and operation. This green design concept runs through the entire building lifecycle, ensuring that the building maintains good energy management performance during use. These application examples fully demonstrate the successful practice of BIM technology and prefabricated buildings in green and low-carbon design. The application of BIM technology has effectively improved resource utilization efficiency, reduced energy consumption and carbon emissions, and provided strong support for promoting the sustainable development of the construction industry, whether in architectural design, construction, or subsequent operation and maintenance stages.

6. The Future Development Direction and Prospects of Intelligent Prefabricated Buildings

With the continuous advancement of intelligent technology, the deep integration of BIM technology with advanced technologies such as the Internet of Things, big data, and artificial intelligence will bring new technological breakthroughs to prefabricated buildings. This multi technology integration model will not only be limited to optimizing architectural design and construction, but will also play a key role in the management and maintenance of the entire life cycle of buildings. One of the development directions for intelligent prefabricated buildings in the future is the comprehensive promotion of intelligent management systems. With the help of BIM technology, real-time sharing and analysis of building lifecycle data can be achieved, making the management of buildings during operation and maintenance more intelligent and automated. Through seamless integration with IoT devices, information such as energy usage, equipment status, and environmental parameters of buildings can be monitored and fed back in real-time. Operations personnel can dynamically adjust based on this data to ensure that the building is always in an efficient operating state. This can not only improve the energy efficiency management of buildings, but also greatly extend their service life and reduce operating costs.

In terms of design and construction, the development of intelligent prefabricated buildings will also pay more attention to modularity and standardization. Future prefabricated buildings will increasingly adopt modular design concepts, achieving more efficient production and installation through unified standards and specifications. BIM technology plays a crucial role in this process, as its digital models can provide accurate data support for the design of different modules, ensuring seamless integration of each module during production and installation. This modular and standardized design can not only greatly shorten the construction period and reduce material waste, but also improve the green and low-carbon performance of the building. With the acceleration of urbanization and the increasingly severe ecological environment, intelligent prefabricated buildings will play a more active role in the future construction of green cities. By combining with the construction of smart cities, intelligent prefabricated buildings can provide more sustainable infrastructure support for future cities. By utilizing BIM technology, buildings in cities will be more closely integrated into the overall energy management and transportation system, achieving energy efficiency optimization from a single building to the entire city. This macro level integration will help promote the development of the entire city towards low-carbon and environmental protection, providing effective solutions for addressing global climate change.

Under the promotion of policies and technology, the popularization speed of intelligent prefabricated buildings will further accelerate. In the future, with the continuous improvement of industry standards and the gradual breakthrough of technological barriers, the intelligence level of prefabricated buildings will reach a new level. This not only requires construction companies to continuously improve their technological level and management capabilities, but also requires extensive cooperation within and outside the industry to promote technological innovation and practical promotion. Through the dual improvement of technology and management, intelligent prefabricated buildings will play a more important leading role in the future green building field, helping to achieve the sustainable development goals of the construction industry.

7. Conclusion

The application of intelligent prefabricated buildings based on BIM technology in green and low-carbon design has shown significant results. By optimizing the entire lifecycle of design, construction, and operation, BIM technology greatly improves the energy efficiency and resource management level of buildings. However, technological bottlenecks and imperfect industry standards remain the main obstacles to its widespread promotion. In the future, with the deep integration of BIM technology and intelligent management systems, prefabricated buildings will make greater progress in modularity, standardization, and full lifecycle management, helping the construction industry's green transformation and sustainable development.

References

[1] Chen Haoran. Research on green building design method based on BIM[J]. Journal of Architecture, 2020, 35(4): 112-118.

[2] Li Yating. Discussion on the technical path and application of green design of assembled buildings[J]. Building Science, 2019, 42(3): 53-60.

[3] Zhang Zhicheng. Research on the application and practice of BIM technology in assembly building[J]. Journal of Civil Engineering, 2021, 39(7): 98-105.

[4] Hu Siyuan. Integration development of intelligent building and green building design[J]. Green Building, 2022, 28(2): 27-33.

[5] Wu Jiaxin. Research on the application of assembly building and BIM technology in energy saving and environmental protection[J]. Building Energy Efficiency, 2020, 31(9): 45-50.