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Digital Application of BIM Technology in the Architectural Design Stage

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Abstract: This paper discusses the digital application of building information model (BIM) technology in the architectural design stage. Taking the large-scale comprehensive development project of Guangxi headquarters base as an example, this paper analyzes in detail how BIM technology promotes the intelligence and refinement of the design process. Through the three-dimensional modeling and simulation analysis of BIM technology, the project design has realized the accurate transformation from concept to operation, which not only improves the design efficiency, but also ensures the construction quality and economic benefits. This paper focuses on the application of BIM in the digital design of building structure, the deepening design of steel nodes, as well as the remarkable results in the comprehensive layout optimization of mechanical and electrical pipelines. Through the collision detection and optimization design of the BIM model, the potential design conflicts and construction problems were found and solved at the initial stage of the project, ensuring the efficient promotion and smooth implementation of the project. The research results show that BIM technology, as the core digital tool in the architectural design stage, is of great significance for improving the overall design level of the construction industry and realizing intelligent construction.

Keywords: BIM technology; Digital application; Architectural design

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1. Introduction

With the rapid development of the construction industry and the rapid development of technology, BIM technology, as an important driving force for the digital transformation of the construction industry, is gradually becoming the core tool to improve design efficiency, optimize construction process and strengthen project collaborative management [1].

By building a three-dimensional digital model, BIM technology not only integrates the information of the whole life cycle such as architectural design, construction, operation and maintenance, but also realizes information sharing and interoperability, providing solid technical support for the scientific management and efficient implementation of construction projects. In the architectural design stage, the application of BIM technology is particularly critical. It breaks the limitation of the traditional two-dimensional design mode, intuitively shows the design concept in the three-dimensional form, and greatly improves the design quality and expression accuracy

[2,3]. Through the BIM model, the designer can review the design scheme in an all-round and multi-angle way, find and correct the problems in the design in time, and avoid the changes and rework in the later construction. Simultaneously, the data in the BIM model is rich and accurate, which provides strong data support for design optimization, cost estimation and resource allocation, and helps the project team to make better decisions and planning. Additionally, the application of BIM technology in the architectural design stage also promotes multi-professional collaboration. Through the BIM platform, professional designers can share models and data, realize real-time communication and feedback, effectively reduce design conflicts and misunderstandings, and improve design efficiency and achievement quality [4,5].

This paper will take the large-scale comprehensive development project of Guangxi headquarters base as an example, systematically explain the digital application practice of BIM technology in the architectural design stage, discuss its application effect and advantages, and look forward to its future development prospects, in order to provide strong support for the digital transformation and intelligent upgrading of the construction industry.

2. Project introduction

2.1. Project overview

This project is a large-scale comprehensive development project located in the headquarters base of Guangxi, whose core goal is to create a modern area integrating residential, office and educational functions. The total area of the project is 92,100 m^2, while the total construction area is 379,700 m^2. Specifically, the above-ground construction area is about 292,500 m^2, and the underground construction area is 87,200 m^2. The diversity of architectural forms is a major feature of the project, which includes high-rise residences, office buildings with frame-core tube structures, frame service centers and commercial facilities. These architectural forms not only enrich the skyline of the area, but also constitute a fully functional modern comprehensive development area.

The project consists of 23 single buildings, whose design and planning reflect a deep understanding of the concept of modern urban complex. The project renderings (as shown in **Figure 1**) further demonstrate this grand blueprint, in which the detailed planning and diversified functional layout highlight the design concept of the project. The BIM model, as the digital core of the project design, transforms this grand blueprint from a concept to an operational reality. Through the 3D modeling and simulation analysis of BIM technology, not only accurately restore every detail of the design effect diagram, but also add rich data information and interaction functions on this basis. Moreover, the BIM model also has strong collision detection and optimization design capabilities, which can find and solve potential design conflicts and construction problems at the early stage of the project to ensure the efficient promotion and smooth implementation of the project.

Figure 1. Project renderings

2.2. Key points and difficult points of the project

2.2.1. The project scale is large and the construction cycle is urgent

The total construction area of the project is 379,700 m^2, integrating residential, education, service and business, forming a complex and large professional span, covering many key fields such as weak current, strong electricity, water supply and drainage. In view of the urgent construction time, how to efficiently complete the design, construction and coordination of large-scale and multi-type buildings in a limited period has become the primary challenge.

2.2.2. Optimization of the comprehensive layout of complex pipelines

The basement area as the equipment concentration and parking space, the mechanical and electrical pipeline arrangement is particularly critical. In the face of problems such as multi-professional pipeline interweaving and limited space, it is necessary to realize the efficient integration and orderly layout of pipelines through fine comprehensive pipeline design, which should not only ensure the convenience of operation and maintenance, but also give consideration into the maximization of beauty and space utilization, so as to ensure the comprehensive realization of building functions.

3. Digital application of project BIM

3.1. Digital design of building structure based on BIM

The application of BIM technology in the digital design of building structure is not only a profound innovation of the traditional design process, but also an important driving force for the transformation of the construction industry into being intelligent and refined. BIM technology, with its powerful 3D modeling, simulation optimization and information integration capabilities, has brought unprecedented convenience and efficiency to the building structure design.

3.1.1. Accurately reserved building holes

In building structure design, according to the pipeline comprehensive adjustment and optimization, using the BIM software for pipeline, through the wall reserved hole position planning, can generate in the early construction accurate reserved hole drawings, which not only can help accurately determine the number of the reserved hole, elevation and size of the accuracy, avoid material waste caused by improper hole setting and rework problems caused by construction delay, but also greatly improve the construction quality and economic benefits of the construction project.

3.1.2. Deepening design of reinforcement nodes assisted by BIM

In order to improve the accuracy and efficiency of the reinforcement construction, the BIM platform is used to build the structural reinforcement model of the whole or specific parts of the project. A detailed drawing of reinforcement nodes is generated through the combination of plug-in assistance and manual fine adjustment. Furthermore, the visual characteristics of the BIM model are used to make the visual disclosure materials to provide intuitive and clear construction guidance for the site construction personnel. This strategy not only reduces the error rate in the construction process, accelerates the construction progress, but also effectively reduces the waste of steel bar materials, and improves the overall construction efficiency, as shown in **Figure 2**.

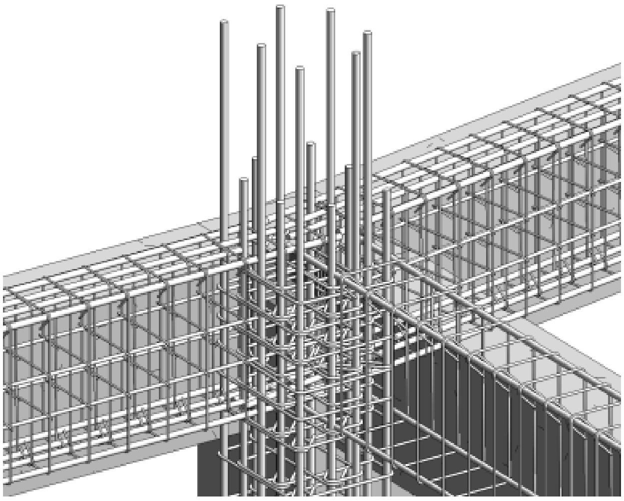


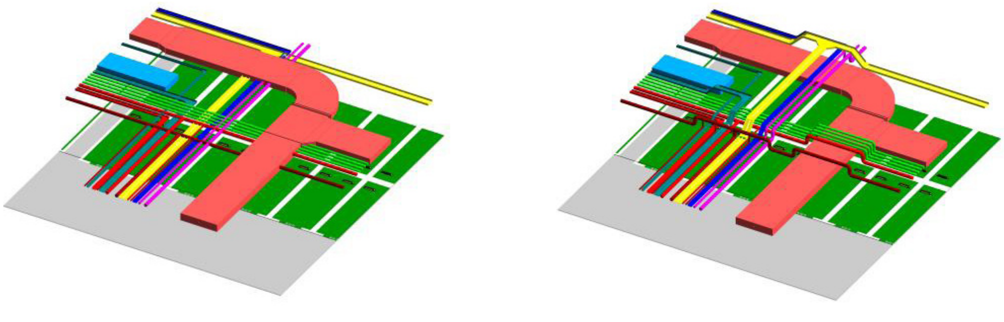
Figure 2. Steel bar node of beam and column

3.2. Electromechanical digital design based on BIM technology

The application of BIM technology in the integrated deepening design of electromechanical pipelines is one of the most extensive and effective fields in BIM practice. It not only involves many professional cross operations, such as heating, ventilation, and air conditioning (HVAC), water supply and drainage, fire protection, strong and weak electricity, and many more, but also requires the centralized arrangement and dense direction of pipelines in the limited space, which brings quite high difficulty in the design and construction. Especially in high-rise buildings or large comprehensive buildings, the comprehensive arrangement of pipelines should not only meet the requirements of functionality and safety, but also take into account the beauty, the convenience of maintenance and the maximum use of the building space.

3.2.1. Pipeline comprehensive optimization design

Based on the integration of full-professional (architecture, structure, electromechanical, etc.) BIM model, a comprehensive collision detection is conducted through BIM software to accurately identify the potential conflicts within the pipeline, between the pipeline and equipment, and between the pipeline and structure. After the collision inspection is completed, a detailed collision report will be automatically generated to clearly mark the location and nature of the collision point. According to the collision report, combined with the construction feasibility, decoration requirements, mandatory specifications and operation and maintenance convenience, the design team proposed the pipeline layout optimization scheme, as shown in **Figure 3**. The scheme aims to realize the scientific, rationalization and aesthetics of pipeline horizontal and vertical layout, to ensure the smooth construction and meet the final use needs.



(a) Before optimization (b) After optimization

Figure 3. Pipeline synthesis

3.2.2. Comprehensive and deepening adjustment of the pipeline

The net height analysis is conducted with BIM software to accurately evaluate whether the net height of each functional area meets the national norms and standards. This step is crucial to ensure the functionality and compliance of the building space. If the net height deficiency is found, the design team will communicate with the owner in time to ensure that the project passes the acceptance smoothly and meets the delivery standards by adjusting the pipeline layout and optimizing the height of the ceiling.

4. Conclusion

Through a thorough analysis of the application of BIM technology during the construction design stage of large-scale comprehensive development projects at the Guangxi headquarters base, this paper draws the following conclusions. Firstly, BIM technology with its robust 3D modeling, simulation optimization and information integration capabilities, has provided unprecedented convenience and efficiency in architectural design. It has significantly improve design quality and construction efficiency. Secondly, in building structure digital design, BIM technology enables accurate reservation of building openings and detailed design of steel nodes, which effectively reduces error rates and material waste during construction, thereby enhancing economic benefits. Finally BIM technology's collision detection and optimization design functions are crucial for the comprehensive layout of mechanical and electrical pipelines. These functions ensure scientifically rational and aesthetically pleasing pipeline arrangements while meeting building functionality and safety requirements. In summary, the digital application of BIM technology in the architectural design stage not only fosters the intelligent transformation of the construction industry but also provides vital support for achieving sustainable architectural design. With the ongoing development and enhancement of BIM technology, its application prospects in architectural design are expected to be even broader in the future.

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Disclosure statement

The authors declare no conflict of interest.

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