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Research on the Review Technology of Building Fire Protection Design Drawings Based on BlM

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Abstract

With the acceleration of informationization in the field of construction, the review process of building fire protection design based on Building Information Modeling (BIM) is increasingly receiving widespread attention from the industry. Study the specific application of BIM technology in the fire design review process, analyze the efficiency of modeling and management, especially in fire simulation and collaborative review. With the precise construction and data exchange of BIM models, the accuracy and review efficiency of fire protection design have been improved. BIM technology has encountered problems in fire protection design review, such as inadequate technical specifications, information security, and a shortage of professional talents. This article proposes targeted measures to promote the efficient application of BIM technology in the review of building fire protection design drawings through optimizing the standard system, strengthening data protection, and cultivating industry talents.

Keywords

BIM technology; Building fire protection design; Fire simulation; Review techniques; data security.

1. Introduction

With the rapid development of technology in the field of architecture, fire protection design is particularly crucial. In the past, the review of building fire protection design drawings mainly relied on paper documents and manual review, which was inefficient and prone to errors. With the widespread application of BIM technology in the field of architecture, a new path has been opened up for the review of fire protection design drawings. By utilizing BIM models, designers and auditors can accurately analyze the structure, materials used, and configuration of fire protection facilities in a three-dimensional space, thereby improving the efficiency and accuracy of the audit work. The application of BIM technology in fire design review is still in its growth stage, and there are still challenges in terms of technical specifications, data management, and talent cultivation.

2. Overview of BIM Technology

2.1. BIM Technology Concept

Building digital management technology BIM relies on model digitization to summarize and integrate information from various aspects of building design, construction, and operation. This technology constructs a three-dimensional building information model that covers the structural characteristics of the building, including key data such as materials used, budget costs, and project progress. Participants in BIM modeling projects - whether designers, engineers, construction teams, or owners - can communicate information and collaborate in a common digital environment, improving project transparency, collaboration efficiency, and

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overall project quality. BIM technology plays a crucial role in the lifecycle management of buildings, covering all stages from design to construction to operation and maintenance, and has become a key driving force for the digital transformation of the construction industry.

2.2. Characteristics of BIM Technology

BIM technology exhibits the following characteristics. The key lies in the comprehensive integration of information. BIM models reveal the three-dimensional structural information of buildings, integrate rich data including building materials, cost budgets, project progress, etc and achieve real-time sharing and updating of information. The collaborative ability of technology is extremely strong, and the BIM work platform allows design, construction, and post operation teams to work together in a unified model environment, ensuring the efficiency and accuracy of information transmission. The visualization function of BIM technology is very prominent[1]. With the help of three-dimensional models, project participants can clearly grasp the design intent and construction details, making it easy to discover and solve potential risks. BIM technology performs well in data analysis, with built-in analysis tools capable of performing complex computational tasks such as energy consumption analysis and structural safety assessment, providing solid data support for decision-making. The full lifecycle management function of BIM technology covers the entire process from design, construction to building operation and maintenance, improving the comprehensive management efficiency of construction projects.

3. Key Technologies for BIM Based Review of Building Fire Protection Design Drawings

3.1. Construction and Management of BIM Models

The construction and management of BIM models are the core steps in the review of building fire protection design drawings based on BIM. Through BIM technology, architects can create a three-dimensional model that includes multi-dimensional information such as building structure, fire protection equipment layout, and material information. Provides visual architectural design solutions and integrates key information for building fire protection design. The construction of BIM models can be described by the following formula:

$$BIM = \sum_{i-1}^{n} (G_i + M_i + F_i)$$

$\boldsymbol{G_i}$ represents the geometric information of the building, $\boldsymbol{M_i}$ represents the material information, $\boldsymbol{F_i}$ represents the layout and related parameters of the fire protection system, and n represents different components in the model. Through this comprehensive multi-dimensional data input, BIM models can accurately simulate the fire performance of various parts of buildings. The management of models is equally crucial. BIM models need to be continuously updated and maintained at different stages of the project to ensure the accuracy and completeness of data. Model management involves version control, permission management, and real-time tracking of fire design changes to ensure information sharing and seamless collaboration among designers, fire engineers, and reviewers. The construction and management of BIM models provide visual support for fire protection design and efficient data foundation for subsequent review processes.

3.2. Fire simulation and analysis techniques

Fire simulation and analysis technology is an indispensable part of BIM based building fire protection design. By combining BIM models with fire simulation software, designers can accurately predict the spread speed, smoke diffusion path, and temperature distribution of fires within buildings. The core formula for fire simulation can be described as:

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$$T = \frac{Q}{\rho C_p V} \cdot \Delta t$$

T Represents the change in temperature inside the building, where ***Q*** is the heat released by the fire, ***P*** is the air density, C_P is the specific heat capacity of the air, ***V*** is the volume of the building space, and Δt is the time interval. Through this formula, fire simulation can accurately reflect the changes in internal temperature of buildings after a fire occurs.

By utilizing the intuitive display function of building information modeling technology, the dynamic simulation of fire can present in detail the diffusion path of fire within the building, which assists designers in exploring the impact of fire on building construction and personnel evacuation. By conducting simulation experiments on various fire scenarios, designers are able to finely adjust fire prevention measures to ensure the structural stability of buildings and the reliability of escape routes in the event of a fire. Simulation and evaluation technology enables building fire protection design to no longer only follow regulatory requirements, but also rely on specific data to achieve scientific evaluation and optimization to enhance the actual effectiveness of design[2].

3.3. Construction of Collaborative Review Platform

The collaborative review system for fire protection design supported by BIM technology is a key innovation in the field of building fire protection planning. The system has built a unified interaction center, allowing architects, technical experts, and fire inspection experts to browse and modify BIM models in parallel within the same interface, promoting real-time information flow and team collaboration. The online collaboration function embedded in the system ensures that all participants can synchronously review and mark the key points of fire protection design, reducing communication barriers and information lag.

Table 1. Collaborative Review Platform Data

Review stage	designer feedback	engineer feedback	fire safety reviewer feedback	completion date
Fire door design	modified	awaiting confirmation	approved	October 10, 2024
Evacuation route optimization	pending optimization	already optimized	pending review	October 15, 2024
Fire extinguishing system layout	confirmed	pending confirmation	pending review	October 18, 2024
Smoke control system	to be modified	confirmed	approved	October 20, 2024

Observing the table, it can be observed that the feedback and current status provided by personnel in different positions regarding different stages of fire protection design. By utilizing a collaborative review system, all members can have a clear understanding of the specific progress of each task and be able to execute corresponding actions in real-time. For example, after the designer modifies the design of the fire door, the fire auditor has approved it, but the engineer has not confirmed it yet. This information prompts the project manager to pay close attention to the engineer's feedback in order to concentrate on ensuring the progress of the project. The establishment of a collaborative review system has improved the efficiency of fire protection design review. By recording and tracking every step of the review process, it has enhanced the traceability and transparency of project management. The collaboration of multiple parties ensures the accuracy and effectiveness of fire protection design, reducing errors in judgment and design caused by asynchronous information.

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4. Problems Faced by BIM based Building Fire Protection Design Drawing Review

4.1. Incomplete technical standards

Although BIM technology has great potential for development in the review process of fire protection design drawings in the construction industry, the relevant technical specifications are not yet perfect. At present, the prevailing BIM standards mostly focus on the design and construction of buildings, and there is a relative lack of specific application guidelines in fire protection design. There is a lack of a unified set of standards to ensure accurate expression of fire protection design in BIM models. Due to differences in the specific practices of applying BIM technology to fire protection design in different projects and regions, there were inconsistencies in the implementation of standards during the review process. The lack of standards is also reflected in the application of fire simulation and analysis techniques, as well as insufficient interoperability between different software and models, leading to confusion among auditors when interpreting different models. The integration between BIM technology and fire safety regulations also has flaws, sometimes making it difficult for fire protection design drawings to smoothly align with current fire safety regulations. Due to the lack of unified standards, auditors may face the challenge of unclear review criteria and processes during task execution, which prolongs the review cycle and may have a negative impact on the accuracy and safety of fire protection design[3].

4.2. Data Security Issues

When conducting fire protection design reviews for building projects supported by BIM technology, data security issues have become an urgent concern. The BIM model contains numerous key building data, construction details, and critical fire protection system configuration information. Once this information is leaked, it will pose a great threat to engineering safety and trade secrets. Given that BIM systems mostly rely on cloud storage and remote collaboration models, it increases the risk of data being illegally invaded, tampered with, or lost. Although BIM software has data encryption and access control functions, many projects often encounter problems such as incorrect permission settings and insufficient data backup due to the lack of comprehensive security management measures in actual operation. With more enterprises and personnel joining BIM collaboration, the frequency and scope of data access have correspondingly increased, making data security management more complex. If the relevant data of fire protection design is tampered with or lost, it will delay the review process of the design drawings and may cause serious security risks. How to ensure the security of BIM platform data and allocate data access permissions reasonably among all participants has become an important issue that urgently needs to be addressed in the current fire protection design review process[4].

4.3. Shortage of Talents

The popularization of BIM technology in the field of building fire protection design has encountered bottlenecks, and one of the key factors is the scarcity of professional talents. As a cutting-edge building information management system, BIM technology has high technical requirements for practitioners, especially in the evaluation of fire protection design. Review experts need to be proficient in BIM model construction and analysis, as well as have a deep background in fire protection design. Experts with dual expertise in BIM and fire protection design are still rare in China's construction industry, and this talent shortage is even more evident in small and medium-sized design agencies and engineering evaluation departments. Many reviewers lack in-depth training in BIM systems, making it difficult for them to proficiently use BIM software or interpret complex 3D graphics, which directly results in some key issues not being detected and addressed in a timely manner during the fire protection

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design evaluation process. The promotion and implementation of BIM technology require cross departmental cooperation, and there are gaps in BIM application capabilities among institutions. The lack of a unified training and certification system further exacerbates the shortage of talent. The shortage of talent has constrained the practical application of BIM technology in fire design evaluation, and has also affected the overall quality and efficiency of the project[5].

5. Solution Strategies for BIM Based Review of Building Fire Protection Design Drawings

5.1. Improve technical standards

The key to ensuring the accuracy and efficiency of BIM fire protection design drawing review lies in the refinement and optimization of technical specifications. The application of BIM technology in the field of fire protection design has not yet formed a unified national standard, resulting in inconsistencies in the review of drawings for various projects. It is particularly urgent to develop a clear set of technical specifications to unify the expression of fire design elements, parameter settings for fire simulation, and review processes in BIM models. The optimization of technical specifications should focus on how to accurately display the layout and design of building fire protection systems in BIM models, and also include standardized requirements for core design elements such as fire protection materials, building construction, and evacuation routes. The implementation of standardized processes can ensure the accuracy and uniformity of fire protection design, and reduce review errors caused by differences in software, tools, or personnel. The formulation of standards should be closely integrated with national fire regulations and BIM technical standards to ensure that the fire protection design drawings in the BIM model comply with current laws and regulations. With the help of unified technical specifications, the review process of building fire protection design drawings will be more standardized and transparent, laying a solid foundation for the safety management of building projects[6].

5.2. Strengthen data security management

In the process of introducing Building Information Modeling (BIM) technology for the review of fire protection design drawings in the construction industry, data security issues have gradually become a major challenge that must be addressed. The BIM model contains numerous details of building construction and configuration information of fire protection systems, all of which belong to sensitive categories. If data is leaked or illegally tampered with, it will cause significant damage to building safety and project confidentiality. It is crucial to strengthen data security protection measures to ensure the integrity and confidentiality of BIM model data. Use high-strength encryption methods during data transmission and storage to prevent unauthorized access to critical information. Build a strict user permission management system that subdivides access permissions for users with different responsibilities. For example, designers can only modify design related content, while reviewers are limited to viewing, reducing the risk of data being misused or manipulated. Develop regular data backup and recovery plans to address potential system failures or data loss caused by network attacks. With the help of these multi-level data security strategies, we can effectively ensure the security of BIM model data and promote the efficient review of building fire protection design drawings.

5.3. Cultivating Professional Talents

The application review of BIM technology in building fire protection design drawings and the cultivation of composite talents who understand BIM technology and are proficient in fire protection design have become the core to break through industry difficulties. Designers, engineers, and reviewers using BIM technology must master advanced 3D construction and

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information management techniques. Fire protection design relies on a solid theoretical foundation and design practice in fire safety. At present, there is a lack of comprehensive talents in the industry who are proficient in using BIM technology and have a deep understanding of fire protection design, which restricts the quality and efficiency of fire protection design drawing review. To solve this problem, it is necessary to strengthen the technical education of in-service personnel, with a focus on in-depth training in BIM software operation, fire design specifications, and fire simulation evaluation. Higher education institutions and vocational training centers should offer professional courses that combine BIM and fire design to cultivate a new generation of professional and technical talents. Enterprises can implement internal skill assessment and continuous education systems to motivate employees to improve their skills. Industry organizations and academic groups should hold special seminars or technical exchange conferences to promote the dissemination and experience exchange of BIM technology and fire design knowledge, accelerate the cultivation of composite talents, and promote the widespread application of BIM technology in the field of fire design[7].

6. Conclusion

The application of Building Information Modeling (BIM) in the evaluation technology of building fire protection design has demonstrated its unique advantages in improving design accuracy and optimizing the review process. In the actual application process, it has also encountered numerous difficulties such as incomplete technical specifications, insufficient data protection measures, and shortage of professional talents. In order to promote the in-depth application of BIM technology in the field of fire design review, it is necessary to supplement and improve relevant technical specifications, strengthen data security protection measures, and enhance the cultivation of professional talents. With the continuous development of BIM technology, its position in the field of building fire protection design is expected to become increasingly crucial. The industry should actively promote the integration of technology and management, provide more comprehensive and accurate support for fire safety in construction projects, and help the industry develop more healthily and comprehensively.

References

[1] Liu Yaji,and Xu Xiaoqian."Rural building cost research practice based on BIM."Academic Journal of Architecture and Geotechnical Engineering 5.8(2023):46-65.

[2] Tokzhan Junussova, et al."Key Drivers for BIM-Enabled Materials Management: Insights for a Sustainable Environment."Buildings 14.1(2023):79-15.

[3] Han Dongchen,Kalantari Mohsen,and Rajabifard Abbas."The development of an integrated BIM-based visual demolition waste management planning system for sustainability-oriented decision-making."Journal of environmental management 351.6(2023):119856-119856.

[4] Waqar Ahsan, et al."BIM in green building: Enhancing sustainability in the small construction project."Cleaner Environmental Systems 11.(2023):100149-118741.

[5] Puyan A. Zadeh,Seungho Han,and Sheryl Staub French."Exploring BIM Implementation Challenges in Complex Renovation Projects: A Case Study of UBCs BRDF Expansion."Applied Sciences 13.23(2023):75-19.

[6] Annamaria Ciccozzi, et al."BIM to BEM for Building Energy Analysis: A Review of Interoperability Strategies."Energies 16.23(2023):157-345.

[7] Yiquan Zou, et al."Parametric Automated Design and Virtual Simulation of Building Machine Using BIM."Buildings 13.12(2023):46-82.