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Research on Construction Operation and Maintenance Management Based on BIM Technology

Sisi Qian*

Nanning College of Technology, Guilin 541006, Guangxi, China

***Corresponding author:** Sisi Qian, qss0315@hotmail.com

Abstract: With the rapid advancement of information technology, Building Information Modeling (BIM) is being increasingly utilized in the construction industry, demonstrating significant potential and value in construction operations and maintenance management. Based on this, this paper conducts an in-depth discussion on BIM technology in building operation and maintenance management, analyzing its challenges and countermeasures, with the aim of providing readers with useful insights and references.

Keywords: BIM technology; Building operation and maintenance management; Information integration

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1. Introduction

With the rapid advancement of urbanization in China, the construction industry has entered a phase of significant growth, making building operation and maintenance management a crucial aspect of ensuring the safe and efficient functioning of buildings. Traditional building operation and maintenance management mostly relies on drawings, manual inspection, and experience judgment, which leads to problems such as resource waste. Therefore, exploring a new, efficient, and intelligent building operation and maintenance management mode has become an important issue to be solved urgently in the current construction industry.

2. BIM technology foundation and overview of building operation and maintenance management

2.1. BIM technology core concept and technical framework

BIM technology is an innovative technological approach in the construction industry that integrates a building's physical and functional characteristics, representing and managing them in a digital format. BIM technology is

developed around the BIM model, which serves not only as a shared knowledge resource for information related to engineering projects but also as the foundation for key business processes such as design, construction, and operation. Through BIM modeling, all project participants can use the same information at the same time to carry out multi-scheme comparison, sustainability analysis, efficient design, construction site control and other business activities, thus greatly improving the decision-making efficiency and quality of engineering projects [1].

In terms of technical architecture, BIM technology relies on key elements such as 3D modeling, data integration, collaboration platforms, multidisciplinary analysis, and project management. Among them, 3D modeling is the cornerstone of BIM technology, which enables designers and engineers to understand the project more intuitively by creating a digital model that includes all the details of the building. The data integration function can ensure the real-time sharing and updating of project information, avoiding the appearance of information islands, and further improve the overall work efficiency [2].

2.2. The definition and content of building operation and maintenance management

Construction operation and maintenance management refers to a series of operation and maintenance comprehensive management activities after the construction project is completed and put into use. This approach effectively integrates key resources such as personnel, facilities, and technology within the building, maximizing resource utilization, reducing operating costs, and enhancing investment returns through an efficient operation and feedback mechanism. The main contents cover space management, asset management, daily management, emergency management, energy consumption management, maintenance management, public safety management, and other aspects, which is the innovation of the traditional property management industry [3].

3. The application of BIM technology in building operation and maintenance management

3.1. Equipment maintenance and asset management

By enabling comprehensive equipment information management, BIM technology supports the entire lifecycle maintenance of construction equipment, including selection, installation, commissioning, operation, and maintenance. It accurately records essential data such as basic information, technical parameters, and maintenance history, establishing a solid foundation for efficient equipment management. During the equipment operation stage, the integration of BIM technology with monitoring systems enables real-time monitoring and data collection of equipment status. This allows for the timely detection of operational abnormalities and the prompt implementation of maintenance measures, effectively extending the equipment's service life. At the same time, BIM technology can automatically generate maintenance plans based on the equipment's operating status and maintenance requirements. By analyzing operational data and maintenance records, it can further optimize these plans, enhancing the reliability and availability of the equipment [4].

In terms of asset management, BIM technology can digitize the information of buildings, equipment, and other assets and use software platforms for management, maintenance, and analysis. BIM technology can realize the integration and visualization of asset information, so that managers can quickly check the location, attributes, status, maintenance history, and other information of assets, to quickly and accurately make decisions on the overall management of assets. Furthermore, BIM technology can also promote the efficiency of asset management and maintenance, including inventory maintenance, equipment tracking, maintenance

management, inspection plan, etc., to make asset management more scientific and reasonable [5].

3.2. Work order management and process optimization

In terms of work order management, BIM technology can provide a detailed building information model, which integrates the design information of building structure, mechanical and electrical equipment, water supply and drainage system, and other aspects. Operation and maintenance managers can quickly locate the location of equipment based on the BIM model, understand its properties and running status, to generate and process work orders more efficiently. For example, when a certain equipment fails, the manager can find the equipment in the new BIM model, generate a maintenance work order by viewing its detailed information, and send it to the corresponding maintenance personnel. In addition, the visual characteristics of the BIM model also make the description of the work order more intuitive and accurate, effectively reducing the delay caused by information asymmetry [6].

The traditional operation and maintenance management process often has problems such as information island and poor communication, which leads to low efficiency of the overall process. BIM technology provides an integrated information platform so that the design, construction, operation, maintenance, and other stages of information can be seamlessly connected. In addition, BIM technology can also be combined with other advanced technologies such as the Internet of Things, cloud computing, etc., to further improve the efficiency and intelligence level of operation and maintenance management. For example, by transmitting the real-time operation data of equipment into the BIM model through the Internet of Things technology, managers can monitor the status of equipment in real-time and automatically generate work orders when necessary. Cloud computing technology provides powerful data processing and storage capabilities, enabling BIM models to be efficiently managed and shared in the cloud [7].

3.3. Energy management and environmental monitoring

BIM models are able to integrate data from smart building systems, including HVAC, lighting, occupancy sensors, etc. By monitoring and analyzing these data in real-time, smart building systems can identify potential energy-saving opportunities, automate control, and optimize algorithms to further reduce energy waste and improve overall efficiency. In addition, BIM technology also supports energy simulation, allowing architects and engineers to simulate and analyze different energy scenarios prior to implementation to determine the most effective strategies to reduce energy consumption and improve building performance. This data-driven approach to decision-making enables significant reductions in energy costs [8].

With the 3D modeling and visualization capabilities of BIM technology, environmental parameters such as air quality, temperature, humidity, etc. can be monitored in real-time and once these parameters exceed the safety threshold, the system will issue an alarm, helping to timely detect environmental problems, and take appropriate remediation measures. This is essential for maintaining the indoor comfort of the building and the health of its occupants. At the same time, BIM technology can also be used in water resources management to optimize the utilization efficiency of water resources and reduce waste by simulating the supply and demand of water resources as well as the recycling of water. In addition, BIM technology also plays an important role in waste management. By combining the waste management system with the building model, it can monitor the amount of waste generated in real-time, provide a scientific basis for the reasonable disposal of waste, and promote the green operation of buildings [9].

4. Challenges and countermeasures of BIM technology in building operation and maintenance management

4.1. Challenges faced by BIM technology in building operation and maintenance management

First of all, the lack of BIM models in existing buildings and the difficulty in data collection is a significant problem. Due to historical reasons or technical limitations, many existing buildings have not established BIM models. Even if these buildings are established later, the models may not accurately reflect the actual conditions of the buildings due to the difficulties in collecting and updating data information. As a result, the application of BIM technology in operation and maintenance management is greatly limited and it is difficult to give full play to its advantages.

Secondly, the integration and compatibility of BIM operation and maintenance management system is the key factor restricting its wide application. At present, there are many kinds of BIM operation and maintenance management systems on the market but the data formats and interface standards between the systems are not uniform, resulting in poor integration of the system, and it is difficult to achieve seamless docking with other systems. This not only increases the complexity and cost of operation and maintenance management but also may lead to the problem of information silos and information inconsistency. In addition, due to the difficulty in sharing and exchanging data between different systems, operations managers face challenges in acquiring and analyzing data, making it difficult to make timely and accurate decisions [10].

Moreover, the automation and intelligence level of BIM technology in operation and maintenance management needs to be improved. Although BIM technology has powerful data analysis and visualization capabilities, these capabilities have not been fully utilized in practical applications. Many operation and maintenance management systems still rely on manual operation and judgment, with a low level of automation and intelligence. This not only increases the cost and time cost of operations and maintenance management but may also reduce the accuracy and efficiency of operation and maintenance management. To improve the automation and intelligence level of BIM technology in operation and maintenance management, it is necessary to introduce advanced algorithms and technical means, such as machine learning and artificial intelligence, to realize intelligent analysis, processing of operation, and maintenance management data [11, 12].

Finally, the market environment is also an important factor restricting the application of BIM technology in operation and maintenance management. At present, the application of BIM technology in the field of operation and maintenance management is still in its initial stage and the market recognition is not high. Many owners and operation and maintenance managers have insufficient understanding of the value of BIM technology and lack of motivation to adopt BIM technology. To promote the application of BIM technology in operation and maintenance management, it is necessary to strengthen market publicity and promotion and improve the visibility and influence of BIM technology. At the same time, it is also necessary to formulate relevant policies and standards to guide and support the application and development of BIM technology in operation and maintenance management [13].

4.2. The application path of BIM technology in building operation and maintenance management

The application of BIM technology in building operation and maintenance management is a complex and detailed process, encompassing multiple stages—from BIM model creation and information integration to the formulation and implementation of operation and maintenance strategies.

First of all, the application of BIM technology in building operation and maintenance management starts from the creation of BIM model. This step usually starts at the design stage, requiring the design team to create highly refined 3D building models using BIM software (such as Revit). This model not only contains the geometric information of the building, such as structure, spatial layout, etc., but also integrates non-geometric information such as the model number and performance parameters of the equipment. This information provides a solid foundation for subsequent operation and maintenance management. In the design stage, the BIM model needs to be named according to the unified standard naming rules, so that it can be efficiently retrieved and used in the operation and maintenance stage. In addition, to ensure the accuracy and integrity of the BIM model, the design team needs to communicate closely with the operation and maintenance team to ensure that all key information is accurately entered [14].

As the building enters the construction phase, the information of the BIM model will be further enriched and improved. Construction teams can use BIM models to conduct construction simulations, predict potential construction conflicts, and optimize construction processes. At the same time, they can also feedback changes in the construction process to the BIM model in a timely manner to ensure that the model is consistent with the actual situation. The BIM model at this stage not only provides strong support for the construction management but also lays a solid foundation for the subsequent operation and maintenance management.

When the building is put into use, the BIM model becomes the core tool of operation and maintenance management. The operation and maintenance team can intuitively manage and monitor the building space, equipment, and facilities by using the BIM model. Through the BIM model, operation and maintenance personnel can clearly see the structure layout of the building, the distribution of equipment, and the connection relationship between various systems. This not only helps operation and maintenance personnel to quickly locate problem areas, but also improves the efficiency of repair and maintenance. In addition, BIM models can also realize real-time update and tracking of equipment information, providing strong support for preventive maintenance and troubleshooting of equipment.

In the process of operation and maintenance management, BIM technology can also be integrated with other intelligent systems (such as the Internet of Things, big data analysis, etc.) to further improve the intelligent level of operation and maintenance management. For example, by connecting BIM models to Internet of Things devices, operation and maintenance personnel can monitor the operating status of devices in real-time and discover and deal with potential faults in a timely manner. At the same time, using big data analysis technology, operation and maintenance personnel can also conduct in-depth analysis of energy consumption, equipment use efficiency, and other data of buildings, providing a basis for formulating more scientific and reasonable operation and maintenance strategies [15].

In addition to the above applications, BIM technology can also play more roles in building operation and maintenance management. For example, in disaster evacuation, BIM models can simulate the evacuation path and escape time of buildings, providing scientific basis for the formulation of emergency plans. In the aspect of building environment management, BIM technology can help operation and maintenance personnel visually observe the overall situation of the building, and reduce the cost and construction difficulty for future maintenance. In addition, BIM technology can also be used in building energy efficiency management, asset management, and other aspects to comprehensively improve the level of building operation and maintenance management.

5. Conclusion

In summary, with the rapid advancement of information technology, the application of BIM technology in the construction industry is continuously expanding, demonstrating significant potential and value in building operation and maintenance management. Through BIM model, operation and maintenance management personnel can intuitively and accurately grasp the information of the building, to make more scientific and reasonable decisions. At the same time, the integration of BIM technology with other intelligent systems has further enhanced the intelligence of operation and maintenance management, ensuring the safe and efficient operation of buildings. It has gradually become an indispensable tool in building operation and maintenance, providing strong support for safe, efficient, and sustainable building management. Therefore, the relevant staff should actively embrace this change, strengthen the research and application of BIM technology, and jointly promote the digital transformation and sustainable development of the construction industry.

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