Journal of Civil Engineering and Urban Planning (2024)
Clausius Scientific Press, Canada

DOI: 10.23977/jceup.2024.060405
ISSN 2616-3969 Vol. 6 Num. 4

Research on the Application of Intelligent Building BIM Technology in High-rise Residential Construction

Rendong Jin*

School of Architectural Engineering, Taizhou Vocational & Technical College, Taizhou, China
993264893@qq.com
**Corresponding author*

Keywords: Intelligent building; BIM technology; High-rise residential buildings; Construction management; Collision check; Design optimization

Abstract: With the rapid development of Internet of Things technology, building information modeling (BIM) technology has made a significant breakthrough in the construction industry, and has shown a wide range of application prospects in the field of intelligent buildings. As the final scene of construction engineering application, intelligent building is equivalent to the life of the building, and its construction process needs efficient information technology support. As an efficient building information model technology, BIM technology collects information of various construction projects and creates three-dimensional models based on it, which can realize comprehensive collection of data information and help enterprises realize effective management of building construction. Because of its complexity and scale, high-rise residential construction needs the support of BIM technology. BIM technology can significantly reduce the problems existing in the construction process, provide efficient technical support for owners, construction units and supervision units, and make more efficient use of construction resources and construction time. Through BIM technology, effective planning of resources, effective control of funds, cost control, etc., can be achieved to improve construction quality and reduce construction costs. Especially in the construction of high-rise residential buildings, the application of BIM technology is particularly prominent in pipeline layout, collision inspection, construction schedule management, safety management and other aspects. This paper aims to discuss the application of BIM technology in high-rise residential construction, in order to solve the problems existing in the current construction and improve the construction efficiency and quality. By elaborating the concept of BIM technology and intelligent building, this paper discusses the application of BIM technology in construction layout, construction schedule management, safety management and design optimization, analyzes the problems faced by BIM technology in high-rise residential construction and puts forward countermeasures. Through the organic combination of BIM technology and the construction process of high-rise residential buildings, the value of BIM technology can be fully demonstrated, and the construction side can help the construction side, the design side and the construction side to achieve integration and integrated application in the project construction process, so as to maximize the engineering benefits, and provide reference and reference for the wide application of intelligent building and BIM technology in the construction industry.

1. Introduction

In recent years, the volume of domestic construction projects has continued to expand, the structural style has become increasingly complex, the construction scale of intelligent buildings has also increased, and the planning has tended to be professional and refined and diversified. Especially high-rise residential projects, because of its long construction period, complex construction technology, and involving many uncertain factors, increase the difficulty of construction management. The traditional construction information management is mainly manual, which is not only prone to errors, but also difficult to realize the dynamic construction management. Therefore, it is urgent to introduce advanced technical means to improve the scientific and efficiency of construction management. Building Information modeling (BIM) system has excellent performance in reinforcement deepening design, construction and decoration, site layout optimization, foundation pit engineering, safety protection engineering, scaffolding engineering, template modeling engineering, Navisworks software application, Revit and computational model mutual guide application, project collaborative management application and so on. Intelligent building is the final scene of construction engineering application, which is equivalent to the life of the building. If BIM technology can be used in the field of intelligent building construction, it can help the construction party accumulate building information and form new value in the process of continuous analysis and induction. The application of BIM technology in intelligent building construction has created a broader development space for the construction industry.

2. Overview of BIM Technology and Intelligent Building

2.1 Basic Concepts of BIM Technology

BIM (Building Information Modeling) technology, that is, building information modeling technology, is a new type of digital technology, applied to the building construction industry. This technology in China's development time is not very long, it originated in Europe and the United States, the earliest by the United States Institute of Building Science and facilities Information Committee jointly defined. In this digital change, BIM technology provides a real-time and effective engineering information base for the 3D model of the building that is consistent with the actual situation. This information base not only contains professional information about the corresponding components of the building, but also includes other information resources such as status information[1]. In addition to containing information, this information base can also display non-component information such as the space and movement form of the building through three-dimensional models, so that the integration degree of the building is constantly improved, and the entire construction process of the building can be effectively controlled. Through these work, the construction quality of the building is constantly improved, so as to effectively reduce the construction cost of the building.

2.2 Definition and Characteristics of Intelligent Buildings

Intelligent building is the final scene of construction engineering application, which is equivalent to the life of the building. Intelligent buildings realize their own functions through intelligent engineering assistance, including intelligent application, intelligent integration, information facilities, building node management, public safety, emergency response system, etc. Intelligent buildings optimize and integrate architecture, systems, services and management, and have intelligent capabilities such as perception, transmission, memory, calculation, judgment and decision making, so as to provide people with safer, more efficient, more convenient and functional

environment sustainable building experience[2]. The construction of smart buildings involves the integration of multiple specialized systems, such as fire fighting, lighting, heating, ventilation, etc. The installation of these specialized equipment is becoming increasingly complex, increasing the difficulty of construction. The applicability of traditional two-dimensional drawings in the construction stage is more and more limited, especially in the case of the intersection of professional pipeline layout, prone to collision phenomenon, increase the difficulty of construction, reduce the cooperation of the construction site, resulting in rework, delay and other problems. Therefore, the application of BIM technology in intelligent building construction can assist the construction party to accumulate building information and form new value in the process of continuous analysis and induction.

3. Application of BIM Technology in High-Rise Residential Construction

3.1 Application of Construction Plane Layout

Construction layout is the basis of high-rise residential construction. High-quality construction layout is conducive to improving construction quality and safety, better managing the later project, fundamentally solving the problem of high cost, and thus increasing project profits. However, the construction process of high-rise residential buildings is a dynamic process, and the layout of the construction site may be adjusted at any time according to the actual project and the requirements of Party A. If the actual construction is carried out in accordance with the initial layout plan of the designer, it is bound to be inconsistent with the real situation, resulting in the actual project cannot be carried out as planned, and may even lead to design rework, resulting in site workloads, waste of materials and costs, and greater workload of engineering personnel, which may seriously lead to safety accidents[3].

BIM technology can solve this problem well. When BIM technology is used for the construction layout of high-rise residential buildings, dynamic site layout can be carried out according to the actual construction situation on site. Through 3D visual management, the size, actual location and material usage of each part of the entire project are monitored and managed, including all required construction process parameters, to facilitate the orderly progress of the project[4].

3.2 Application of Construction Schedule Management

The construction period of high-rise residential buildings will be affected by many factors. In the actual construction, some uncontrollable factors will occur, which will lead to the delay of the construction process and the difference between the construction period and the design scheme. If the construction time continues to extend, the construction period will become more and more obvious differences, which will affect the later interior decoration and sales.

The traditional construction schedule management method has many problems, such as incompatibility of information interaction and fragmented information integration, which cannot help construction projects to build a real information chain of the whole life cycle, resulting in communication barriers between units and professions, and forming "information islands"[5]. The use of BIM technology can greatly improve this situation. Through BIM technology, the construction progress can be reasonably planned in the early stage, a model can be established, the construction process can be simulated, possible problems can be found in advance, and corresponding measures can be taken to adjust (see Table 1).

In actual operation, the HD camera can be comprehensively covered in the construction site, and the management personnel can effectively and comprehensively grasp the situation of the construction site through monitoring, and find the safety hazards and unqualified situations in the

site and modify them. At the same time, BIM technology can clearly show the construction progress of housing construction projects, and managers can make changes through relevant measures, and optimize the current management mode of housing construction project progress is not clear phenomenon.

Table 1: Application of BIM technology in construction schedule management

Application content	Specific description
Construction schedule planning	Through the BIM model, the construction progress is reasonably planned to ensure that it is carried out as planned
Simulated construction	The BIM model is used to simulate the construction process and identify possible problems in advance
Real-time monitoring	Through high-definition cameras, real-time monitoring of the construction site, timely detection of security risks
Progress display	Through the BIM model, the construction progress is displayed, the unfinished project is clearly defined, and the corresponding measures are taken

3.3 Applications in Security Management

Safety management in high-rise residential construction is very important. There are many problems in the traditional security management, such as the identification of security risks is not timely, and the security management is not in place. Through BIM technology, security risks can be effectively identified. By simulating the real construction process, each step of the construction can be understood in advance, so that the condition of the construction site can be known in advance, and the project management personnel can preview the formulated construction plan in advance to see whether it meets the needs of the site and modify the plan in advance (see Table 2).

Table 2: Application of BIM technology in security management

Application content	Specific description
Security risk identification	BIM technology is used to simulate the construction process and identify potential safety hazards in advance
Construction plan preview	The construction plan is previewed by BIM technology, and problems are found and modified in advance
Real-time monitoring	Through the 3D visual interface, each staff on the site is located and monitored
Safety performance improvement	Improve the safety performance of the project and ensure that the benefits of the whole project can be realized smoothly

BIM technology allows construction managers to control the safety situation of the site at any time in a dynamic situation. At present, on-site construction is a constantly changing process. Through the safety management of BIM technology, various on-site workers can be located and dynamically monitored through the 3D visual interface, thus improving the safety performance of the project[6].

3.4 Application in design optimization

The design process of high-rise residential buildings is complex, involving the integration of

multiple professional systems, such as structure, water supply and drainage, HVAC, etc. There are many problems in the design process of traditional 2D drawings, such as inaccurate collision detection and inadequate design optimization. BIM technology can use the data designed by model parameterization to represent the component information of the building body, and these model information is unified with the actual application attributes of the building components, that is, there is a corresponding relationship. In the application stage of BIM technology, the parameterization of design building components has great practical significance, and the parameter attributes must be defined in advance in strict accordance with relevant standards and specifications.

In high-rise residential projects, collision detection for multiple majors can be performed using Navisworks Manage software. The specific approach is to use this software to integrate the completed BIM models of architecture, structure, mechanical and electrical engineering in Revit software, output the corresponding Revit models of each specialty into a specific format file, and then integrate them into Navisworks Manage, refresh the software and summarize the nwd model files generated in the early stage. To realize the model's intelligence and the target's synchronous update[7]. In this way, collision points can be found more accurately and design optimization can be carried out accordingly (see Table 3).

Table 3: Application of BIM technology in design optimization

Application content	Specific description
Collision detection	Collision detection is carried out through BIM technology to find the cross, interference and conflict between various professional components in the building
Design optimization	According to the results of collision detection, optimize the layout of pipeline facilities and adjust the specifications of beams and columns
Intelligent management	Through BIM technology to achieve intelligent management, improve design efficiency and accuracy

4. Problems faced by BIM Technology in High-Rise Residential Construction and Countermeasures

4.1 Problems

(1) Shortage of technical personnel

The application of BIM technology is not only the use of a software or tool, it involves the digital management of the entire building life cycle, from design, construction to operation and maintenance and other aspects, which requires a professional team and a high level of technical support. However, the current construction industry has a serious shortage of professionals with BIM technology capabilities. This includes not only designers who can skillfully operate BIM software, but also construction personnel and managers who can use BIM technology for construction management, cost control and schedule planning[8]. Due to the shortage of technical personnel, it is difficult for many enterprises to give full play to the advantages of BIM technology, which limits its effective application in high-rise residential construction.

(2) High investment cost of hardware and software equipment

The application of BIM technology cannot be separated from the support of high-performance hardware and software equipment, which is not only expensive, but also needs regular maintenance and update. For some construction enterprises with insufficient financial strength, this is a large economic burden. Therefore, how to reasonably control the input cost of hardware and software

equipment has become an important factor affecting the application of BIM technology in high-rise residential construction.

(3) Imperfect standards and norms

The standards and specifications of BIM technology are an important guarantee to ensure its effective application. However, at present, different regions and enterprises have different application standards and specifications for BIM technology, resulting in incompatible problems in the data format and information exchange of BIM models. This not only increases the difficulty of BIM technology application, but also affects its promotion and application effect in high-rise residential construction.

(4) Data security issues

Building project data is the core of BIM technology application. With the wide application of BIM technology, the problem of data security has become increasingly prominent. Since BIM models contain a large amount of building information, such as structure, equipment, materials, etc., once the data is leaked or illegally accessed, it will have a serious impact on the business secrets of enterprises and the smooth progress of projects. Therefore, how to protect the security of BIM data and prevent data leakage and illegal access has become an important issue to be solved in the application of BIM technology.

(5) The acceptance of management is not high

Although BIM technology is widely used and recognized among technicians at the job level, there is often a low level of acceptance of new technologies by management. This is mainly due to the fact that the management may be accustomed to the traditional way of working and thinking inertia, and lack of in-depth understanding of the advantages and application value of BIM technology, which will lead to the promotion and application of BIM technology in construction management.

4.2 Policies

(1) Strengthen personnel training and introduction

Through internal training, enterprises organize employees to participate in BIM technology-related training courses, including software operation, theoretical knowledge, practical application, etc., so that employees can gradually master the core knowledge and skills of BIM technology. The company encourages employees to participate in seminars, exchanges and other activities in the industry to broaden their horizons and understand the latest trends and development trends of BIM technology. Secondly, the technical strength of the team can be supplemented by the introduction of external talents. Enterprises actively cooperate with universities and scientific research institutions to jointly train BIM technical talents and attract outstanding graduates to join enterprises [9]. At the same time, the enterprises introduce BIM technical talents with rich experience and professional skills through recruitment, headhunting and other ways to improve the overall strength of the team. Construction enterprises can also establish an incentive mechanism to reward employees who have outstanding performance in the application of BIM technology, stimulate the enthusiasm and creativity of employees, and promote the wide application of BIM technology in the enterprise.

(2) Optimize hardware and software device configurations

In terms of hardware and software equipment investment, construction enterprises need to scientifically and reasonably configure the hardware and software equipment required by BIM technology according to their actual situation and project requirements. This includes a thorough evaluation of the existing hardware and software equipment to understand their performance, compatibility, etc., to ensure that they can meet the application requirements of BIM technology. At

the same time, according to the scale and complexity of the project, the appropriate hardware and software equipment is selected to meet the needs of design, construction, operation and maintenance and other aspects. In this process, construction companies also need to weigh the cost performance of equipment, and strive to obtain high-performance equipment at a reasonable cost. In addition, construction enterprises can further reduce the cost of equipment input through flexible ways such as leasing and sharing, establish a solid cooperative relationship with equipment suppliers, and obtain the required equipment through leasing, thus reducing the pressure of one-time investment[10]. Sharing device resources with other enterprises can not only improve device utilization, but also effectively reduce the idle rate of devices and optimize resource allocation.

(3) Establish uniform standards and norms

In order to promote the wide application of BIM technology in high-rise residential construction, it is very important to build a sound BIM technology standard system. This includes the development of a unified BIM modeling specification, clear modeling accuracy, format, naming rules, etc., to ensure that BIM models between different teams can be smoothly docking and sharing. Enterprises should also establish data exchange standards, specify data exchange formats, protocols, etc., to ensure that data between different software can be accurately and efficiently transmitted and exchanged. Enterprises should also support the establishment of a data quality inspection mechanism to implement strict monitoring and management of data quality to ensure the accuracy and integrity of data. It is also necessary to formulate a standard process and management system for the application of BIM technology, and clearly define the responsibilities, processes, standards, etc., of each link, so as to ensure the effective implementation and scientific management of BIM technology in the construction process.

(4) Strengthen data security management

In view of data security issues, construction enterprises need to take comprehensive measures to protect the data security of BIM technology. Including the establishment of strict data access control mechanism, to achieve the fine management of user rights, data access rights of different users are subdivided and managed to ensure that data access is limited to authorized users. At the same time, enterprises should strengthen data encryption and backup measures, encrypt sensitive data, ensure the security of data during transmission and storage, and regularly back up data to prevent data loss or damage and rapid recovery. Construction companies should also actively cooperate with professional data security organizations, using their advanced technology and rich experience to jointly improve data security capabilities and ensure that BIM technology data security is worry-free.

(5) Promote the management to accept and apply BIM technology

Through organizing trainings, seminars and other activities, the advantages and application cases of BIM technology are introduced to the management level, so that the management level can have a deeper understanding of BIM technology. Enterprises establish BIM technology application demonstration projects to demonstrate the advantages and effects of BIM technology in construction management. Through the demonstration of practical cases, the management can see the significant effects of BIM technology in improving construction efficiency, reducing costs and improving quality, and enhance the confidence and acceptance of the management. In addition, construction enterprises can also strengthen communication and exchange with the management, understand the needs and expectations of the management, and adjust the application scheme and management mode of BIM technology according to the actual needs, so that BIM technology can better serve the project management and enterprise development. At the same time, the management is encouraged to actively participate in the application and promotion of BIM technology, and jointly promote the widespread application and development of BIM technology in high-rise residential construction.

5. Conclusion

This paper deeply discusses the application of BIM technology in high-rise residential construction, and analyzes its specific application and advantages in construction layout, construction schedule management, safety management and design optimization. BIM technology can significantly improve construction efficiency and quality, reduce construction costs, enhance construction safety, and promote multi-party cooperation. However, the application of BIM technology also faces some challenges, such as the shortage of technical personnel, high input cost of hardware and software equipment, imperfect standards and specifications, data security issues, and low management acceptance. These problems can be effectively solved by strengthening personnel training and introduction, optimizing hardware and software equipment configuration, establishing unified standards and norms, strengthening data security management, and promoting the acceptance and application of BIM technology by management. In the future, with the continuous progress of technology and the deepening of application, BIM technology will play a more important role in the field of intelligent buildings, and interdisciplinary research needs to be strengthened to combine BIM technology with other advanced technologies to promote the intelligent and modernization process of the construction industry.

Acknowledgements

2022 University Visiting Engineers Cooperation Project in Zhejiang Province "Research on BIM Based Technical Standard Compilation in the Bidding Stage of Construction Projects" (FG2022254).

References

[1] Hao Q .Analysis of Construction Technology of High-rise Residential Building Engineering[J].Journal of World Architecture, 2017, 1(3).

[2] Anh T N, Thanh P N, Tien S D .Key Factors Affecting the Application of Building Information Management (BIM) in Management of High-Rise Building Construction Volume[J].Journal of Physics: Conference Series, 2021, 1783(1): 2089-2090.

[3] Wu K, Soto D G B, Adey T B, et al.BIM-based estimation of vertical transportation demands during the construction of high-rise buildings[J].Automation in Construction, 2020, 102985-102987.

[4] Tuan T K .Problematic issues emerging during BIM implementation process in construction organizations[J].Built Environment Project and Asset Management, 2024, 14(6):892-913.

[5] Deng R, Li C .Digital Intelligent Management Platform for High-Rise Building Construction Based on BIM Technology[J].International Journal of Advanced Computer Science and Applications (IJACSA), 2022, 13(12).

[6] L. K D S, Vasanth K .Application of BIM for Effective Construction Safety Management in High Rise Buildings[J]. IOP Conference Series: Materials Science and Engineering, 2022, 1255(1).

[7] M D S, Juliastuti, A A P .Clash detection analysis with BIM-based software on midrise building construction project[J].IOP Conference Series: Earth and Environmental Science, 2020, 426(1):012002.

[8] Moeisra A D, Juliastuti, Insyira H A, et al.Accelerating the middle – rise building construction duration using BIM 4D, a case study in central Jakarta[J].IOP Conference Series: Earth and Environmental Science, 2024, 1324(1).

[9] Kim H, Roh S, Kim J .Embodied carbon of BIM bridge models according to the application of off-site prefabrication: Precast concrete applied to superstructure and substructure[J].Developments in the Built Environment, 2024, 100550-100552.

[10] Rui M .Application Analysis of BIM Technology in Construction Engineering Cost Management[J].Journal of Electronic Research and Application, 2024, 8(5):52-57.