

# The Innovative Application of BIM Technology Analyzed from the Perspective of Intelligent Construction Site

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**Abstract.** With the continuous development of the construction industry, the concept of smart site is gradually emerging, and building information modeling (BIM), as a key force to promote the construction of smart site, has attracted much attention for its innovative application. This paper focuses on the application of BIM technology in smart construction sites, and comprehensively expounds the changes brought by BIM technology through in-depth theoretical discussion and practical case analysis. The research summarizes the innovative application modes of BIM technology in smart construction sites, including visual planning and design, multi-professional collaborative work, simulation and optimization of construction process, and intelligent quality and safety management. Taking the petition center project of Beijing City Sub-center as an example, the specific application effects and challenges of BIM technology in the whole life cycle of the project are analyzed in detail. At the same time, it points out the shortcomings in the current research field, such as the insufficient integration of BIM technology with other emerging technologies, the lack of professional talents, and the inconsistency of data standards. This paper puts forward strategies including strengthening technology integration, improving talent training system, and establishing unified standards, so as to promote the wider and more effective application of BIM technology in intelligent building sites.

**Keywords:** Smart site; BIM technology; Innovative application; Construction industry; Digital transformation.

## 1. Introduction

With the acceleration of economic globalization and urbanization, the scale of the construction market continues to expand. As the core link of the construction industry, its efficiency and quality are directly related to the development of the entire industry. However, the traditional construction engineering has long existed problems such as resource waste, low efficiency, frequent safety accidents and environmental pollution, which have become the bottleneck restricting the progress of the industry.

At the same time, the rapid development of computer technology and artificial intelligence, and the arrival of the 5G era have brought new opportunities for technological innovation in the field of construction engineering. The gradual integration of digital and information technology makes the construction process more intelligent, efficient and environmentally friendly. For example, the application of building information modeling (BIM) technology can accurately predict various situations in the construction process at the early stage of design, optimize construction schemes, and reduce rework and waste [1]. At the same time, the proposal and implementation of the concept of smart site realize the real-time monitoring and management of the construction process through the use of technical means such as the Internet of Things (IoT) and big data analysis, and significantly improve the safety and quality of the project [2].

At present, the digital transformation of construction engineering has achieved initial results, and numerous studies and practical cases have proved the great potential of integrating digital and information technology into the construction process. However, this transformation process is also faced with a series of challenges, including high cost of technical equipment input, adaptability of

construction personnel skills and cognition, data sharing and information security issues [3]. These limitation factors require continuous innovation and in-depth exploration by the industry.

This paper focuses on the deepening application of computer technology and artificial intelligence in the construction of construction projects, aiming to reveal the innovative practice of BIM technology in the construction of smart sites and its positive impact on improving engineering efficiency, reducing costs and improving construction safety [4]. The research theme focuses on the application status, advantages and challenges of the latest technology in construction engineering.

## **2. Smart Construction Site**

### **2.1. The Concept and Characteristics of Smart Construction Site**

"Smart Construction site" is an innovative concept and model that deeply integrates advanced information technology with construction site management. Its core objectives are to achieve digital, intelligent and fine management of construction sites, improve construction efficiency, ensure construction quality and safety, reduce costs and reduce environmental pollution [5]. As an important embodiment of the digital transformation of the construction industry, the smart site has shown many distinct and unique characteristics. After using the smart site system, the construction status of the site can be detected in real time at any time, the potential hidden dangers existing in the construction can be found in time, and reasonable and effective measures can be taken to optimize the construction plan and effectively improve the quality of construction. With the continuous development of The Times, the project management mode is also constantly developing. Employees can communicate with each other through the information management mode, quickly implement various projects, effectively eliminate the drawbacks existing in the traditional construction management mode, promote the management of enterprise construction projects, and accelerate the speed of project construction.

### **2.2. BIM Technology**

BIM technology is a transformation process from two-dimensional model to three-dimensional model, and this process is also extremely important for the construction of "smart site". Because to a certain extent, BIM technology also indirectly affects the development of the "smart site". One of the more common functions is construction simulation. It means that after the construction schedule is developed and completed, the construction schedule is associated with the BIM model through software to simulate the construction process. Comparing the actual project progress with the simulated progress, it can be intuitively seen whether the project is lagging behind and analyze the reasons for lagging, so as to ensure that the project is completed as planned.

With the application and popularization of BIM technology, the application depth of BIM technology in the construction stage has gradually deepened. It can improve the project schedule and quality, reduce the construction cost, and improve the management level of the entire project [6]. Therefore, it is of great significance to explore the application of BIM technology in the construction stage to achieve fine resource management.

### **2.3. The Correlation between Smart Construction Site and BIM Technology**

The combination of smart construction site and BIM technology complement each other. BIM injects accurate data and scientific planning into the smart site, while the smart site provides real feedback and dynamic optimization for BIM technology. The two work together to promote the construction industry to move towards the direction of digitization and intelligence, and achieve more efficient, better quality and safer project construction.

BIM technology provides a strong data base and model support for smart construction sites. The smart construction site is the extension and expansion of BIM technology application. With the help of various advanced iot devices, sensors and intelligent monitoring systems, it collects actual data from

the construction site in real time and creates accurate 3D building information models. It covers the whole life cycle information of construction projects from design to construction and even operation and maintenance. Such dynamic data interaction enables the BIM model to be continuously updated and optimized, closer to the actual construction situation, and thus better guide the construction process [7].

### 3. The Innovative Application of BIM technology in Smart Construction Sites

#### 3.1. Fine Management of Construction Schedule

In the context of smart construction sites, BIM technology has brought revolutionary changes to the fine management of construction progress. With its powerful 3D modeling and information integration capabilities, BIM technology can accurately simulate the construction process, providing a solid foundation for construction schedule planning and cost control. The traditional project management mode mainly relies on experience or subjective judgment, it is difficult to accurately predict the project progress and cost. BIM technology can build a digital platform to realize multi-frequency information sharing and synchronization, achieve cross-professional and cross-team collaboration, and further improve the level of project management [8]. Table 1 compares traditional construction sites and smart construction sites in many ways.

**Table 1.** Comparison table between traditional construction site and smart construction site

| Classify                        | Traditional Construction Site   | Smart Construction Site   |
|---------------------------------|---|---|
| <b>Information management</b>   | (1) Relying on manual recording<br>(2) Poor information flow<br>(3) The efficiency of collaborative work is low.  | (1) Real time collection, transmission, and storage of information<br>(2) Efficient collaboration and information sharing |
| <b>Construction supervision</b> | (1) Relying on manual reporting<br>(2) The cost of rectification when problems are discovered is very high.       | (1) Real time monitoring and dynamic adjustment of construction progress<br>(2) Conduct real-time quality inspection      |
| <b>Safety management</b>        | (1) Relying on manual inspection<br>(2) The form of safety education is simple, but its effectiveness is limited. | (1) Comprehensive and real-time safety monitoring of the construction site<br>(2) VR immersive safety education           |
| <b>Resource management</b>      | (1) Open management of materials and equipment<br>(2) Resources are idle or scarce.                               | (1) Intelligent and refined management<br>(2) Reasonably allocate resources based on data analysis                        |

In terms of construction schedule, BIM technology can provide accurate modeling. Each detail of the building is displayed to the designer in a digital way, so that the designer can intuitively understand the overall structure of the building and the mutual relationship between various parts. In the system management background, the participants can understand the actual construction progress and actual resource consumption information. At the same time, BIM model, construction schedule and construction resource plan information can be obtained. Through the comparative analysis of the two, the difference of construction progress can be calculated to know whether the supply of construction resources meets the construction demand [9]. It can not only reduce the design errors, but also

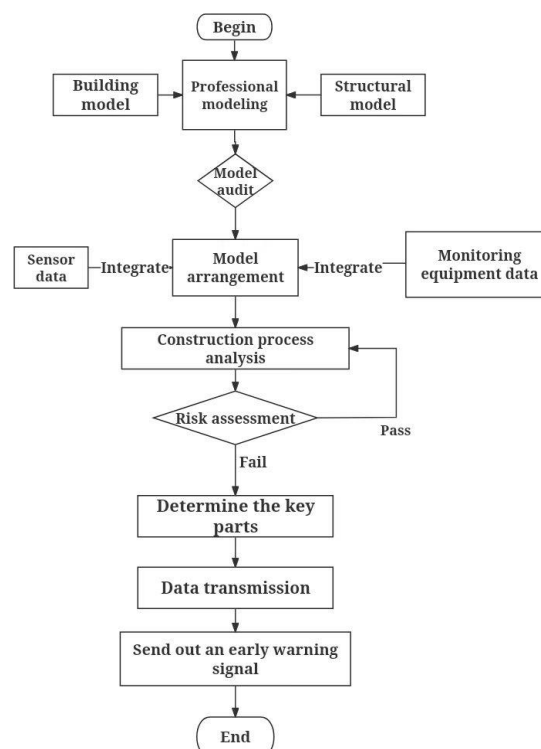
improve the accuracy and integrity of the design, so that the quality of the design has been greatly improved.

In terms of cost control, BIM accurately reflects the materials of construction projects on the basis of digital models. Managers can monitor the project progress and project cost in real time, discover and correct existing problems in time, and avoid overspending of funds and waste of resources. At the same time, the BIM model also records the building components and construction process, forming an accurate bill of quantities and cost budget. Based on these data, the management personnel can scientifically analyze and predict the cost, and formulate a reasonable budget plan accordingly, so as to achieve refined cost control [10].

### 3.2. Dynamic Monitoring and Early Warning of Security Risks

BIM technology integrates geometric information, physical information and functional information of a project by constructing a three-dimensional building model. In the pre-construction stage, BIM models can be used to simulate the construction process and collision detection, and potential safety risks can be found in advance, such as the risk of falling from high places, the risk of hitting objects, and the risk of mechanical injury.

Security early warning management mainly includes two aspects: security early warning warning sending and security warning feedback. In the construction process, the IoT technology is used to integrate various sensors on the construction site (such as displacement sensors, stress sensors, environmental monitoring sensors) with the BIM model to achieve real-time dynamic monitoring of the construction process. The data collected by the sensor can be transmitted to the BIM platform in real time, and through comparison and analysis with the preset data in the BIM model, safety risks in the construction process can be found in time. After judging and analyzing the specific information collected at the construction site, if the monitored object is in an unsafe state, an early warning signal will be immediately sent to the front-line operators and construction safety management personnel, either through the interface reminder or through the binding of mobile phones to receive the reminder information. It is convenient for on-site safety inspection personnel to communicate with construction personnel in a timely manner [11].



**Figure 1.** Safety monitoring flow chart

When the monitoring data exceeds the preset threshold, the BIM platform will automatically send a safety warning message. Early warning information can be passed on to relevant personnel in a variety of ways, such as mobile phone text messages, emails, on-site alerts. At the same time, the BIM model will display the warning area and the warning content accordingly, helping relevant personnel to quickly locate the problem and take effective emergency measures. In addition, through the analysis and summary of historical early warning data, the early warning model and threshold setting can be continuously optimized to improve the accuracy and timeliness of security early warning [12]. In order to more clearly demonstrate the process of BIM safety monitoring, as shown in Fig. 1.

### **3.3. Digital Management of Facilities and Equipment**

Facilities and equipment as an important part of the project, its efficient management for the smooth progress of the project and quality assurance is of key significance. Digital management can promote the standardization and standardization of the management process of facilities and equipment. The BIM integrates various parameters of the facility, such as model, specification, production date, and installation location. This not only provides an intuitive visual reference for managers, but also ensures the accuracy and integrity of information, avoiding problems caused by information omissions or errors in traditional management. At the same time, BIM's digital management system can realize real-time monitoring and dynamic tracking of facilities and equipment. By using sensor technology and the IoT, data such as operation status and maintenance status of facilities and equipment can be transmitted to the BIM platform in real time, so that managers can grasp the working status of equipment at any time, discover potential faults and safety hazards in time, and take measures for repair and maintenance in advance, thus significantly improving the reliability and service life of equipment [13]. BIM technology can also work out a more scientific and reasonable maintenance plan based on factors such as the use frequency and operating environment of the equipment, combined with historical maintenance data, and through data analysis and prediction algorithms.

## **4. Case Study**

### **4.1. Beijing City Deputy Center Administrative Office Area Petition Center Project**

The project is located in Beijing. The total construction area is 47,900 square meters. The project uses the intelligent construction platform for information integration management. Unified coordination of labor, safety, quality, production, technology, hazardous projects, site monitoring and other work on the platform. Data communication between new and old platforms is realized by sharing data. In view of the heavy and difficult construction plans of the project, the node Revit model is drawn, feasibility simulation is carried out, and construction plans are prepared, such as the construction plan of the tall mold frame and the construction plan of the steel structure. The model is used for three-dimensional dynamic visualization to ensure the information transmission through the three levels of disclosure. It solves the problem of plan preparation and comparison, as well as information transmission in the process of disclosure [14].

In terms of safety and quality management, the application of the platform provides a more transparent means of information management for the project. The project manager can easily check the on-site safety and quality problems found, supervise the implementation of the overdue situation, and check the implementation of management requirements by tracking the types of problems. The application of high mold monitoring equipment for high mold safety monitoring, once the site construction exceeds the safety value, the sound and light alarm will be issued immediately. This kind of safety and quality management is more transparent. It improves the effect of safety and quality management and reduces the occurrence of safety and quality accidents.

## **4.2. Evaluation and Suggestions for Improvement**

Although the BIM application results of the project are remarkable, there is still some room for improvement worth exploring to pursue more perfect results.

Functional requirements and the overall layout of the city were fully considered in the planning and design phase of the project, so that the center can effectively function and integrate with the surrounding environment. At the same time, the application of BIM technology, intelligent security system and green building technology shows the advanced nature and innovation of the project, and improves the quality, safety and sustainability of the building. Strict construction management and quality control ensure that the project is completed on time and has reached a high-quality standard. The reasonable functional layout meets the actual needs of the petition work and provides a convenient and comfortable service environment for the public.

However, the project's petition channels are not diversified enough. At present, the petition center mainly relies on on-site reception and telephone consultation, and lacks new media channels such as the Internet and WeChat. The feedback mechanism is not perfect. The feedback of the handling results of some letters and visits is not timely, which leads to the low satisfaction of citizens on the work of letters and visits. In this regard, the channels for petitioning can be broadened. The Internet, big data and other technologies should be fully utilized to build a diversified petition platform and improve the feedback mechanism for petitions. At the same time, the tracking management of letters and visits can be strengthened to ensure that the processing results are timely and accurate feedback to the society.

At the same time, resource allocation can be optimized. According to the volume of letters and visits, the staff and facilities should be rationally adjusted to improve the reception capacity of the letters and visits center. Strengthen technical training for staff to better operate and maintain advanced equipment and systems to maximize their effectiveness. In the follow-up operation of the project, the channels and ways of public participation can be further increased, and more feedback can be collected, so as to continuously improve service quality and improve emergency plans and facilities, so as to cope with possible emergencies and ensure the continuity and stability of petition work.

## **5. Conclusion**

This paper explores in depth the innovative application of BIM technology in smart construction sites, aiming to provide theoretical support and practical guidance for the digital transformation of the construction industry. By combing relevant theories and studying practical cases, the following main conclusions are drawn:

- (1) By summarizing the innovative application of BIM technology in smart construction sites, it clearly presents its significant advantages in visual management, collaborative work and intelligent construction, providing strong support for the digital transformation of the construction industry.
- (2) Taking the project of Petition Center in the Administrative office area of Beijing City Deputy Center as an example, the whole process from planning, design, construction to management shows the specific application effects of BIM technology in the actual project, and points out the problems existing in the implementation process in terms of personnel technical level and data management.
- (3) The research also reveals the shortcomings of the current BIM technology in the application of smart construction sites. First of all, the integration of BIM technology and the actual equipment and process on the construction site is not close enough, resulting in certain deviations and delays in information transmission. Secondly, the data security and privacy protection mechanism still needs to be strengthened, and a large number of site data will be leaked or tampered with, which will bring serious consequences. Moreover, the application of BIM technology has high requirements for personnel quality, and at present, there is a relative shortage of professionals with comprehensive application ability of BIM in the industry, which limits its wider promotion.

In the future, the development trend of BIM technology will be more clear. With the popularization of 5G networks and the improvement of cloud computing capabilities, the transmission and processing of BIM data will be more efficient and convenient, and remote real-time collaboration will become possible. At the same time, the combination of VR and AR technology with BIM will bring a more immersive experience to building design and construction, further improving the efficiency and quality of communication. In addition, BIM technology is expected to play a greater role in the operation and maintenance management of the whole life cycle of buildings, and realize the optimization of building performance and the fine management of assets through intelligent equipment monitoring and data analysis.

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