

BIM-Based Strategies for Construction Quality Control in Building Engineering

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Abstract: In order to improve the construction quality and steadily promote the improvement in the level of the construction industry, this paper expounds BIM-based strategies for construction quality control. This paper first identifies the factors affecting the construction quality, analyzes the advantages and value of the application of BIM in construction, and finally analyzes the scenario of applying BIM for future references.

Keywords: BIM; Building engineering; Construction quality control

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1. Introduction

The demand for buildings is expanding in tandem with the global acceleration of social construction and the constant growth in the number of people, which plays a vital role in promoting the development of the construction industry. The number of construction companies is also gradually increasing, with more people being interested in engendering profits from the construction industry, thus heightening the competition in this industry^[1]. The construction engineering industry has now become the core industry supporting social and economic development. The characteristics of construction engineering and the working environment at the construction site suggest that this industry is in fact a “high-risk” industry^[2]. Especially in recent years, many construction engineering safety mishaps have occurred, causing people of all walks of life to pay more attention to this aspect. Casualties due to unnecessary potential safety hazards in the actual construction process bring serious economic losses to enterprises and unstable factors to the society^[2]. Research related to construction quality has always been a major focus of the construction industry, and the stability of construction quality is not only related to the safety of social groups living in buildings, but also affects the interests of the construction party^[3]. In short, the research on construction quality control and management of related projects is a comprehensive work, which is accompanied by the technical requirements of the project construction unit for project implementation, scientific mix proportion, and standardized material use. Although the asset management of the construction process and the later stage of the service project have attracted attention from the construction side, there are still many loopholes in the operations of the construction supervision and technical personnel in the implementation stage. In addition, the construction period is usually long, and many construction operations involve dangerous high-altitude and field operations, making the impact on the construction project more uncontrollable and affected by these factors to a certain extent. This puts forward higher requirements for the safety guarantee of the construction party. Under the social background of the positive development of market economy, the construction industry must constantly adjust the market structure. The industry can only continue to develop

if an ideal control system in terms of economy and profit is established.

2. Factors affecting the technical quality of building construction

There are often many uncertainties in the construction process. Factors causing low construction quality are seen throughout the entire project. They include human, material, object, environment, method, and other factors. These factors affect the quality of construction technology, and eventually the completion of the construction project ^[4].

2.1. Human factors

People play an important role in the construction process and take the lead in completing construction projects. Large-scale construction projects usually require more manpower. Construction technology and quality work often require personnel with high comprehensive quality and professional level, but in practice, many construction units have low professional level and weak awareness of safety management, thus affecting the quality to a certain extent ^[5]. Construction technology is mostly affected by human factors. It is controlled by people, which is most likely to result in the low construction quality.

2.2. Material factors

The most basic factor to ensuring construction quality is the use of verified building materials. The quality of materials determines the quality of construction technology. However, some construction units often only seek immediate interests and use non-suitable building materials to reduce material costs, thus leading to quality issues in completed buildings.

2.3. Environmental factors

Since most buildings are built outdoors, weather, terrain, hydrogeology, and other conditions have a great impact on construction projects, thus increasing the uncertainty in the construction process of these projects.

2.4. Mechanical factors

The majority of construction projects use complex and large-scale construction technology that necessitates a huge quantity of mechanical equipment. As a result, when mechanical equipment fails, the overall construction quality of the construction project is easily affected.

2.5. Process factors

Due to technical reasons, the construction process tends to be complex, as there are many kinds of processes, with each process having different quality standards. Therefore, the construction process is not covered, and the standards and requirements of each process are not specified. In that case, the technical quality of the construction cannot be guaranteed. In the current market economy, due to the nonstandard construction contract management and fierce competition in the construction process, many construction enterprises have reduced the standardization of construction management in order to improve their economic interests. Therefore, enterprises lack quality control. Due to the continuous development of the society and economy in China, the improvement of the construction market cannot keep up with the market economy. Many enterprises move forward in pursuit of economic benefits ^[6]. Using cheap materials to reduce costs, construction projects do not have quality supervision; in addition, the purpose of the construction contract has been disregarded, becoming a dead letter, which does not play any role in the actual construction process. Construction supervision is an important means of construction quality control, and supervision is also an important link and influencing factor in construction technology. A quality supervision of construction technology is very important for quality control because it covers all aspects of construction projects from

design and development to material procurement and the actual construction process. Due to the lack of supervision or effective supervision measures for ensuring the quality of construction projects, many construction enterprises have hidden dangers in the later use of buildings, which are prone to safety incidents and unimaginable repercussions.

3. Advantages of applying BIM in the construction quality management of prefabricated buildings

3.1. Improve the efficiency of quality control

The scientific application of BIM in the construction management of prefabricated buildings makes the presentation of information data more efficient, scientific, intelligent, and electronic. With the help of visual data platform, managers can manage the construction quality more scientifically and effectively, with the operation being more scientific and standardized. It effectively makes up for the shortcomings of traditional paper information storage and transmission methods, with safer information storage, more efficient construction quality management, more accurate control of relevant parameters, and improved management efficiency ^[7].

3.2. Construction quality control based on simulation

BIM features a simulation function that mimics the construction scheme analysis mode, which can organically associate the 3D model of a building structure with time and develop a 4D spatial construction model as well as a 5D communication technology platform on this basis. Moreover, the structural framework and architectural appearance of each construction link can be simulated and compared with the actual construction appearance to determine any quality issues ^[8]. The building information model based on BIM allows for different modeling with various accessories in different types and sizes. In that way, the supervision department and relevant technicians can fully understand the construction information and further optimize the installation process and implementation process. The construction will be transparent, and the construction quality will be fully guaranteed.

3.3. Traceability of the entire process in terms of quality responsibility

Taking a prefabricated building as an example, its construction involves multiple links, of which different personnel are responsible for. Based on the scientific application of BIM, the role of internet of things and mobile devices can be maximized to link the construction process organically. By maximizing the role of cloud storage and other technologies, construction instructors can achieve control and guidance remotely, as well as real-time supervision and management of the construction process. In addition, various indicators and parameters formed during the construction process can be uploaded to the cloud, so that relevant staff can fully, timely, comprehensively, and accurately gauge the actual situation in the construction process ^[9]. They will be able to achieve supervision and traceability of the entire construction process and its quality.

4. Application of BIM in construction quality control

4.1. Before construction

4.1.1. Drawing review

A good drawing review enables one to determine the loopholes and correct them in time, which would help reduce errors in the construction process and improve the quality as well as efficiency of the construction project.

4.1.2. Collision inspection and reserved hole design

Before pipeline and electromechanical installation, BIM can be used to identify conflicts and possible issues, so as to enable specific measures to be taken for optimization and repair. By determining the problems in

advance and reducing the rework in the later stage, the project cost and quality issues caused by rework can be reduced.

After completing the BIM model of the electromechanical pipeline, the BIM representative outlines the opening in each professional drawing of the project. Thereafter, it is necessary to further design the details of the reserved opening. This allows the construction personnel to plan their location and drill holes in advance to prevent mistakes from occurring in later stages. BIM can also be used to integrate multiple professional models of architecture, structure, electromechanics, and so on. These models can be transmitted to Navisworks for cloud computing, and the collision results can be derived from the software after calculation ^[10]. By referring to the output of the software, if problems are found, the model can be reoptimized after correction.

4.1.3. Site layout optimization

It is necessary to use BIM to establish the site environment model, plan and organize office and living facilities in advance, as well as manage the main entrances and exits, temporary roads, material storage areas, rotating fields, mechanical equipment, and so on, in order to avoid construction delays ^[11]. It realizes cross-task interaction and uses the BIM model to coordinate and manage the general layout of the construction in each stage.

4.2. During construction

4.2.1. Construction process simulation

Before the formal construction of complex structural shear wall using BIM, shear wall construction is used to simulate the construction process from reinforcement binding to wall formwork and concrete pouring. In the simulation process, on the one hand, problems can be found in advance to optimize and solve the problems; on the other hand, the construction technology can be disclosed to frontline construction personnel to help them familiarize with the construction technology and process. Therefore, it can effectively improve the quality control effect in the construction process of shear wall.

4.2.2. Change in construction scheme design

Temporary changes are common in the construction process, but the effect after the change is often difficult to visualize. After comparing the technical variables, feasibility, economic benefits, and constructability of the construction method after the site change, the comparison scheme before and after the change can be identified and submitted to the head office. The BIM collaborative management platform can be used to communicate with the design unit online and provide data sheets.

4.2.3. BIM mobile application

The on-site construction management personnel can use the mobile terminal of the self-developed C8BIM collaborative management platform to view the model, plan, component details, size, elevation, and some other areas that are difficult to view on a handheld mobile device. Quality inspection is a great convenience. The construction management personnel can intuitively identify on-site quality issues, record them on the mobile equipment, and rectify them in time ^[12].

4.2.4. UAV and intelligent platform application

UAV is used to conduct on-site inspection, identify potential safety hazards in time, inspect the construction quality in an all-round way, and collect video data of key construction nodes. It may be beneficial to generate data information instead of manual mapping, create a 3D model, and compare it with the BIM model to identify construction quality issues in time.

4.3. After construction

4.3.1. Information management

The construction cycle of an engineering project is usually long, especially for large-scale projects with complex structure. From the beginning of the project to the completion of the entire project, there will be an accumulation of a large number of engineering data files. All these materials are printed on paper for storage. This process requires a lot of time and experience, with a low efficiency. Dealing with these materials is a challenge for data owners. When there are problems in the construction process, it will be inconvenient to look for the drawings, and it will also be a challenge to obtain accurate information in a timely manner^[13]. Using the archival data collaborative management platform can effectively alleviate this problem. During modeling, BIM technicians can directly input the material and equipment parameters into the model, and the BIM collaboration platform allows the site manager to upload the data collected in the construction process to the BIM model in time, so as to realize the availability of data. At the later stage of the project, when there are quality problems, relevant personnel can key in the corresponding number in the collaborative management platform and identify the cause of the problem as well as the person responsible for it.

Inputting material and equipment parameters as well as construction information (technical parameters, manufacturer, production date, construction date, construction unit, warranty period, etc.) in the BIM model and linking them with the corresponding engineering design will be convenient for various construction management drawings and subsequent asset management operation and maintenance^[14-16].

4.3.2. QR code data management

BIM administrator can use a BIM-related software to generate a QR code for each component in advance and then paste the QR code into the built component. By scanning the QR code of digital products, such as mobile phones or tablets, one can quickly view the information model of the corresponding part, and managers themselves can intuitively inspect the information model and detection data to provide information convenience.

5. Conclusion

In conclusion, construction quality is affected by many factors. In general, they can be divided and placed under five categories: people, things, environment, machinery, and technology. In order to avoid the influence of these five factors on the construction quality, it is necessary to strengthen the application of BIM to improve the efficiency of construction quality control, realize the simulation experiment design of construction quality, and ensure that the quality responsibility of a construction project is clear with good traceability. Construction quality control can be divided into before construction (drawing review, collision inspection and reserved hole design, as well as site layout optimization), during construction (construction process simulation, construction scheme design, BIM mobile application, and intelligent platform application), and after construction (information management and data information management). BIM can be applied throughout the entire process of building construction quality control.

Disclosure statement

The author declares no conflict of interest.

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