BIM-based solution of management optimization and inspection during construction of a Stadium

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Abstract. The construction of sports venues has the characteristics of large-scale in construction, complex structure and long construction period, which has a high requirement for construction scheme, technology, process and coordination management. Taking an Olympic Sports center as an example, this paper introduces the application of BIM technology in stadium project in details. Planning the overall application and implementation, as well as the technical disclosure of complex nodes and construction process in visual have been conducted with BIM technology which improve the construction quality. Moreover, the project cloud computing platform is established, and the material tracking system, progress control system, safety monitoring system are completed by applying the BIM technology which improve the construction environment of safety and civilization in site and the information management. And simultaneously, by simulating technical scheme of key and complex parts, steel structure hoisting scheme has been adjusted to reduce the structure deformation and ensure the high safety and accuracy. Finally, aims of ensuring the quality of the project, reducing the cost, shortening the construction period and saving materials are achieved.

1. Introduction

Building information model refers to the digital expression of physical properties and functional properties of buildings [1], which was first proposed by Chuck Eastman in the United States in the 1970s, and later widely recognized in practical engineering applications, and gradually introduced to countries all over the world [2]. Especially in the 21st century, BIM has gradually become an important tool to solve engineering construction management with the rapid development of computer software and hardware and the vigorous promotion of BIM technology in various countries [3]. For example, Zhang J P and other scholars began to combine BIM and 4D technology to solve problems related to structural safety and conflict during construction [4]. Irizarry J improved visual monitoring of construction supply chain management by integrating and applying GIS and BIM [5]. Cao Kun et al. carried out site layout, safety protection isolation column layout, simulated emergency evacuation drill and hazard source investigation based on BIM technology, which fundamentally solved the potential risk factors in construction and further ensured the construction safety [6].

For large, special-shaped buildings such as stadiums and gymnasiums have the characters of complex structure, large span, and large project volume, which brings severe challenges to the application of BIM technology. For Olympic Sports center project, the application of BIM technology in information
management of construction process, scientifically arrangement of resource planning, safety risks controlling, reducing of material waste and construction efficiency improvement has been introduced in this paper.

2. Project overview and construction difficulties of the project

Taking an Olympic Sports center project which covers a total area of 516,000 m² and a total construction area of 464,000 m² as an example. It contains a stadium, a comprehensive hall, a tennis hall, a natatorium and an apartment for athletes. The diagram of the project is shown in figure 1. The main building material of the Olympic Sports center is steel structure which is widely used in the field of infrastructure construction because of its superior performance, but then, accompanied with the characteristics of large span and complex structure form for those projects, it requires high field construction management and exposes many problems. For this project, it is mainly faced with the following key points and difficulties in the construction process: 1) The steel structure and grandstand of the project require a large amount of prefabrication, which is relatively difficult to process and lift; 2) It is difficult in detail design for curtain wall and electromechanical pipeline, and the project requirements a high accuracy in installation and positioning of curtain wall; 3) Because of the complex of structure joints, it is more prone to cross collision; 4) The scale of concrete formwork and part of the beam height used in the project is too large which may induce a high construction risk; 5) The construction period is very short that brings a certain difficulty in construction quality. In view of the above problems, solutions have been put forward to overcome the on-site difficulties with BIM technology.

3. BIM-based solution of management optimization during construction

3.1. Optimization of construction general layout management

1) Planning for general layout. Form a three-dimensional geomorphological model by collecting the site information before the project starts with UAV photography and the three-dimensional visibility of BIM. Planning site construction plane includes the layout of temporary construction, the installation and dismantling of large machinery, the positioning of construction stacking yard, and the planning of construction road, etc. Meanwhile, the simulation of management is carried out with Navisworks. According to the construction progress, the facilities on site are updated and managed, and the panoramic information of the project is collected regularly by the UAV to form the full cycle image data of the project so that the layout of the construction site can also be updated in real time based on the same progress. The aerial view collected by UAV is shown in figure2.

2) Simulation management of organization on construction site. According to the construction characteristics of this project, the 3D simulation of BIM system is fully utilized to realize the dynamic control of the construction scheme, so as to analyze the actual situation of the construction site. The BIM 3D model is simulated in stages based on the construction progress plan to observe the rationality of the traffic organization plan in each main stage, the use of large equipment, material stacking yard, the processing site and the use of overlay facilities. By synthetical simulating the surrounding
environment and access road, the piling up of the mechanical equipment and building materials on the construction site and the fire prevention on site, the construction site can be comprehensively planned and managed effectively to ensure a reasonable and order project.

3.2. Optimization of schedule management
In construction management, 3D technology is applied to record the complex situation of the project site effectively and completely with its advantages of fast measurement speed, high precision, convenient operation and so on, which can directly reflect the actual construction situation on site by comparing with the design model. Then with plan management software Zebra, the entire construction process can be managed and planned and the project progress arrangement can be obtained. The three-dimensional building models and schedule plans of various majors are imported into Navisworks software to simulate the construction schedule in each stage to analyze the rationality of the project construction schedule and adjust the plan in time.

Simultaneously, the construction simulation can be combined with the project budget so as to prepare construction materials, machinery and labor in advance to ensure the smooth implementation of the whole project and reduce the construction period as much as possible which realizes the application of BIM 5D simulation [7-8].

3.3. Optimization of resource coordination and management
After calculating the engineering quantity accurately with BIM 5D software, the project resource management and optimization can be implemented in construction process. Material procurement and labor allocation in the project can be controlled according real-time calculation of the quantities of different construction stages, so as to optimize the utilization of construction resources and to speed up the construction progress.

3.4. Optimization of quality and safety management
The professional digital construction model and fine decoration model have been set up with the combination of BIM and VR technology, as shown in figure 3. By considering the requirements of technical quality, common quality problems, control measures and the target of quality control, the technical disclosure of the construction process is carried out, and the construction scheme is simulated dynamically to display the construction process in visual, so that the information error caused by the plane drawings offering unspecific information can be avoided. Quality and safety inspection is shown in figure 4.

Figure 3. VR roaming experience
Special materials and components are tracked with the BIM material management system to ensure the materials and components under the monitoring during the whole process from entry to installation and construction, which guarantees the quality of materials and improves the construction quality. The BIM technology can also be used in monitoring of the site construction in real-time and in construction rehearsal to predict the risk factors during the construction process, so as to prevent and eliminate potential safety dangers in advance. Moreover, VR technology simulation can be used in safety education and training, so that the field workers can experience the fictitious work environment, know the hazard source and improve safety awareness.

4. BIM-based solution of inspection during construction

4.1. Collision inspection
The structural joints are complex for such a large-scale and special shaped building, and there will be more likely to collide in cross. Therefore, collision inspection needs to conduct for each specialty model. When there is not enough space between the components or parts and collision will happen, optimization suggestions are put forward and the model are adjusted preliminary. Meanwhile, situations are fed back to the design institute for change confirmation, and the detailed construction drawings of each specialty is formed after refining, optimizing and improving. Then integrate the models provided by other specialized departments and inspect the collision again and the specialty models are detail designed so as to solve the conflicts between scheme design and site construction. Finally, the ultimate detailed design mode is submitted for approval and review and the construction drawings are issued to guide the site construction. The collision inspection and technical disclosure of complex nodes are shown in figure 5.
4.2. Completion inspection and acceptance
1) The BIM model has been basically completed with the help of Revit, Tekla Structures and Navisworks software which should be integrated and verified to form the finished model.

2) Integrate and proofread all professional BIM models. The original design model should be corrected in real time to make the BIM model more real and more accurate in the whole construction process simulation of architecture building, building structure, electromechanical equipment, and in the information of huge project and a large number of components to form a complete model.

3) Check the integration result of completion information model. Examine the integration status of various information through simulation demonstration with professional software.

4) All participating departments are organized to compile the final completion data, and sort it out as basic data of BIM completion model.

5) Verify the accuracy of the information provided by the participating departments, not also including the data of building and its foundation, but also the information of all departments.

5. Conclusion and Prospect
Under the engineering background of diversified functional requirements and scientific construction technology, the application of BIM technology plays an important role in improving the overall design quality of steel structures. Based on the analysis of application in large-scale projects such as stadiums and Gymnasiums, the collaborative management of each specialty during construction has been improved, however, BIM technology still has a great room for improvement and innovation. Engineers should make full use of the advantages of BIM Technology on the basis of traditional construction mode, improve practical activities, and promote the design and construction of engineering projects in China to a new level by application of BIM Technology [9].

Acknowledgments
This work was financially supported by China MCC17 Group Co., LTD （NO.2021RD07 & No.CY2020-1）

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