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Study on Fine Management of Construction Engineering Projects Based on BIM Technology: Taking the Construction of Group C Project of Zibo Cultural Center as an Example

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Abstract: The roof steel structure of group C project of Zibo cultural center is composed of steel truss, welded H-shaped steel and large-diameter steel pipe embedded parts. The construction of embedded parts of inclined cylinder overhanging steel structure is difficult. The stair square tube ladder beam requires precise angles and radians, complex processing, and construction site setting out is difficult. A three-dimensional visual building information model has been established for this projects which includes several aspects which are as follows: the development of the post anchor construction technology of large steel sleeve embedded parts with inclined cylinders based on Building Information Modeling (BIM) technology, multi discipline synthesis and collision optimization, the net height optimization of electromechanical pipelines, fine reinforcement management, BIM virtual construction template. Through this planning, 14908 pipeline collisions, including 236 major collisions have been eliminated. BIM is used in handling and solving problems with the construction unit and the supervision company. This greatly improves the project work efficiency and saves meeting time. Through optimization of electromechanical line collision and secondary masonry layout, more than RMB 9 million has been saved in terms of personnel and materials, effectively reducing material losses, saving manpower, and significantly improving the implementation efficiency of the project. Based on the on-site simulation, the project planning scheme of the enterprise was adjusted, efficient work allocation with less idle time were ensured, and the correct utilization of project funds and time were ensured. The original extensive annual control and monthly control have been dynamically and accurately controlled to realize the dynamic understanding of the profits and losses of the project, and effectively reduce the occurrence of non-ideal situations.

Keywords: Zibo cultural center; Steel structure; Building Information Modeling; Fine control

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1. Introduction

In recent years, the construction industry at home and abroad has developed rapidly, but various problems have emerged in the development process, such as unnecessary waste of resources, improper construction organization design, engineering quality and safety accidents, etc. [1,2]. Therefore, based on BIM Technology, many scholars at home and abroad have studied how to effectively improve construction efficiency and reduce resource investment [3,4]. At the same time, in accordance with China's double carbon policy and build green buildings, many construction enterprises in China have introduced BIM Technology into the construction process of a large number of domestic construction projects, so as to improve

construction efficiency, optimize design and reduce resource waste [5]. Hence, this paper thoroughly analyzes how to realize the fine management of construction projects based on BIM technology using the C group project of Zibo cultural center as an example.

2. Project overview

The group C project of Zibo cultural industry center is located at the southeast corner of the intersection of Liantong road and Xinhuan West Road, Zhangdian District, Zibo City, with a total construction area of 76782 m^2. The ground buildings include culture and science museum, ceramic art museum. Among them, the culture and science museum cover an area of 21,503 m^2, with the height of the main building at 28.4m, and the ceramics museum covers an area of 38,539 m^2, with a building height of 46m.The project was officially commenced on May 15, 2016 and completed on April 29, 2019.

3. Engineering difficulties and characteristics

3.1. Construction of large-span and large-size roof steel truss

The steel structure of the museum roof is composed of steel truss, welded H-shaped steel and large-diameter steel pipe embedded parts. The top elevation of roof steel truss is 33.875 m, the maximum span is 70.5 m, the number of members is about 2500, and the maximum section size of steel beam is h1500 $\times$ 400 mm while the maximum weight of a single member is 11.5 t.

Tekla software is used for three-dimensional modeling, which shortens the drawing time and improves the drawing accuracy. The preliminary planning through the three-dimensional model is conducive to a more thorough analysis of components and safer, more reasonable and reliable scheme [6].

3.2. Construction of large steel sleeve with inclined cylinder

It is difficult to install the embedded parts of the inclined cylinder overhanging steel structure. The large grouting material installation hole of the inclined cylinder is mainly used for the foundation treatment of the inclined cylinder overhanging steel structure, and requires precise positioning, axis displacement, elevation, and highly accurate construction of the embedded parts. The reserved hole for steel grouting material has a large volume, high load, difficult construction quality control and inconvenient operation, and the tower crane cannot be lifted; There are many anchor bars in reserved holes, and the inclined column head reinforcement is dense, so it is difficult to install the steel sleeve embedded parts in place; The installation height of steel sleeve embedded parts is high, and high-altitude operation are dangerous.

3.3. Construction of steel structure rotating stairs

The steel structure rotating staircase is located at the entrance of the science museum hall of the project. Its horizontal projection is oval, supported by nine large-diameter circular steel columns, and its overall height reaches 19.3 m. It is directly connected to the third floor of the science museum from the commodity department on the first floor underground. The square tube ladder beam of stairs requires precise angles and radians, complex processing which is difficult to set out on site. In addition, there are also problems of large stair size and difficult indoor hoisting.

Tekla was used to draw the steel structure rotating stairs, and the details of important nodes were optimized and adjusted. Combined with the mapping function of Tekla, the plane, elevation and section drawings were exported, and the special nodes were indicated in tables to guide the later construction [7].

3.4. Professional construction of complex electromechanical installation

There are many mechanical and electrical installation disciplines in the project, and the pipeline layout is complex therefore requiring precise height. During the construction of mechanical and electrical installation

works, the coordination and management of equipment procurement, installation, commissioning, operation and other aspects are involved. There are many subcontracts which causes difficulties in coordination. Secondly, the mechanical construction requirements cover a wide range of aspects, including electrical engineering, automation, electrical engineering and other fields, which require mechanical practitioners to master all-round engineering knowledge.

4. BIM based technology application and deepening design

4.1. Joint review of drawings based on BIM

Through the three-dimensional visualization of BIM mode, the design problems in the drawings can be more directly reflected which greatly improves communication [8]. The problems reviewed were sorted out according to disciplines and regions. Then, information such as drawing problem sources, problem descriptions, pictures (modification suggestions) were provided, and the review results of the final BIM drawings were generated.

4.2. Three-dimensional planning of construction site based on BIM

BIM Technology is used to conduct scientific three-dimensional design for the construction area, including the design of residential area, office, material production and storage area, site traffic, etc., which directly expresses the construction site information [9-12]. This ensures smooth traffic on the construction site, facilitate the operation of workers, and effectively prevent secondary handling and accidents.

4.3. Post-anchor construction technology of large steel sleeve embedded parts of inclined cylinder based on BIM

The visualization of BIM technology is used to assist the project in the research of quality control (QC) results, and the post anchor construction technology of large steel sleeve embedded parts with inclined cylinders was developed in this project.

4.4. Multi-discipline synthesis and collision optimization based on BIM

BIM is used for collision test [13] in which it can detect situations that are not found in various plan views and different collision situations. Finally, 14908 collisions were found, including 236 major collisions, which minimized unnecessary material and economic losses such as rework.

4.5. Clear height optimization of electromechanical pipeline based on BIM

BIM Technology is adopted to realize the clear height control inspection [14]. By scientifically and reasonably arranging various pipelines within the limited floor height, the available space on the ground is saved to the greatest extent. Besides, the overall sense of space for construction is improved. The engineering design intention and connection with construction products are also better completed. Moreover, various pipelines are arranged in an overall and reasonable manner to well meet the engineering application function, economy and aesthetic standards. Thus, the purpose of reducing the cost or improving the appearance is realized. In the construction of this project, the net height of the basement is adjusted reasonably, and the local equipment pipelines are adjusted and optimized to meet the needs of the construction owner.

Machine room pipeline optimization - the design of the equipment room uses the early deepening technology of BIM [15]. This ensures that the facilities and pipelines can be arranged uniformly in a limited space, realizing the unified arrangement of a variety of special pipelines, making the overall design of the machine room more complete, reasonable and beautiful. Through the preliminary planning, it meets the needs of many but not miscellaneous lines, orderly arrangement, clear hierarchy, correct direction, correct

pipeline delivery position and beautiful layout.

4.6. BIM based audit meeting

In depth technical meetings are often held to discuss BIM model collision detection technology and comes out with reasonable solutions. After the meeting, the outcomes are summarized and collision inspection reports according to the main collision conditions are provided. The construction party will then adjust the BIM design scheme of the discipline according to the conditions in the collision inspection report [16].

4.7. BIM based construction drawings

Through the construction platform of smart site construction, 3D modeling and 2D computer-aided design (CAD) files can be introduced into the cloud service management system, and the site manager can query through a mobile client. Using this method, the site manager can obtain drawing data very simply and efficiently, which is convenient for site management.

4.8. BIM based integrated support design optimization

Through BIM technology, the design and installation of integrated supports and hangers are realized. Besides, the air path, water channel, fire pipeline, cable tray, etc. are reasonably planned in order to save space, facilitate maintenance, and have a beautiful and tidy environment.

5. Project fine management based on BIM

5.1. Pine management of reinforcement

Due to the large amount of reinforcement used in this project, Guanglian Dayun proofing software and reinforcement site management software are used to help project managers realize site proofing and improve efficiency by using BIM Technology in reinforcement plan management, site proofing, processing optimization, material management, etc. [17].

5.2. BIM virtual construction template

By using BIM technology, with the help of its three-dimensional and visual characteristics, the construction process can be digitized and virtualized to replace the traditional entity template, at the same time realizing the visual preview. This creates a multi angle and all-round query of model information and make the construction disclosure process more efficient and easier for the construction personnel to master. In this way, not only does it save cost, but the use of materials and the generation of construction waste is also reduced. Besides, green construction is also realized.

5.3. Visual technical disclosure

In this project, the direct insert plate pin type formwork support will be used, which is a new type of formwork support. Compared with the traditional fastener type steel pipe scaffold, this formwork support has no zero parts, avoiding the loss and waste of zero parts. At the same time, this formwork support is convenient to set up, quick to construct and is efficient. It speeds up the construction process, and reduces labor intensity and the rental cost of reusable materials.

5.4. Application of two-dimensional code in measured real quantity

The two-dimensional code technology is effectively used in the actual measurement work. The staff can see the actual measurement results of various places anytime and anywhere, grasp the existing problems in the early construction process, and summarize the parts under construction, thus further improving the quality of project construction. On one hand, the problems existing in the previous construction process can

be understood; on the other hand, post skills can be improved by learning the measured results.

5.5. Construction progress management

The presentation method of virtual construction through construction simulation based on NavisWorks is an evolution of construction simulation in BIM technology. Applying it to the construction process of the project can effectively realize the early guidance of construction, process control implementation, and finally check the construction, so as to achieve the fine control of the project.

5.6. Construction quality management

Project quality control is performed using the “intelligent construction integrated management platform”. The site manager directly takes photos of the project quality problems on the mobile terminal at the construction site, and uploads the pictures to the platform. The system identifies the area where the project quality problems occur, defines the person in charge of rectification, the rectification time, etc., and sends the rectification results to the person in charge's personal mobile terminal. After the person in charge completes the rectification, the system determines the end. This is therefore in accordance to the “Plan Do Check Act” (PDCA) principle. At the same time, the problem record is linked to the BIM model. If the problem is not solved, it will always be nailed to the corresponding position on the BIM model. If the problem is not solved within the time limit, it will automatically remind relevant personnel. This allows the informatization and intelligence in quality management.

5.7. Construction safety management

It is necessary to use big data cloud processing platform, combined with the labor real name system management system, process the information of construction personnel in a timely and provide feedback in a timely manner, and conduct real-time supervision on site staff. It is necessary to monitor the construction site in real time and give early warning of unsafe construction behaviors in advance.

5.8. BIM + VR application

By introducing the VR experience safety education system developed by Ruigezhi Network Technology Co., Ltd. and restoring the safety accidents in the production process of the actual building, educated and experienced personnel can achieve better understanding of the causes of accidents, experience the process of accidents, and better understand the production technology and safety precautions.

5.9. BIM + UAV Technology

By introducing the BIM based UAV shooting method, the project sets the UAV flight photography route and scenic spots, and grasps the layout and image progress of personnel, materials, machines and tools at each time, so as to help control and adjust the construction deployment of the project, and finally master the construction image resources of the complete project.

6. Refined management effect based on BIM technology

Work efficiency: There are a total of 14908 pipeline collisions in this project, including 236 major collisions. The BIM model is used to with and solve problems for construction units, supervision units, engineering design units, etc. in a timely manner. This in turn greatly improves work coordination effect and saves meeting time.

Design advantages: BIM Technology is adopted to realize design advantages. According to the design of electromechanical line collision and secondary masonry layout, the cost department has saved about RMB 9 million according to the comprehensive calculation of labor and capital, effectively reducing

material economic losses, saving labor costs, and significantly improving the implementation efficiency of the project [18-20].

Construction organization optimization: Through building simulation, the construction organization planning of the enterprise is further optimized. Four large peaks and one large trough are combined with the actual construction, and finally optimized into a reasonable peak to reduce unnecessary idling. This is to ensure the rational planning and use of resources and time.

Contract control: The original extensive annual control and monthly control are dynamically and accurately controlled to dynamically understand the profit and loss and excess savings of the project, so as to effectively prevent the occurrence of unreasonable situations.

7. Summary and prospect

With the continuous development of BIM technology and information technology, more and more construction projects will phase out the original rough construction management mode and carry out fine management based on BIM technology. This requires future construction units to continuously cultivate a new generation of construction technicians, integrate construction technology and BIM technology, and build high-quality construction projects according to the national double carbon policy.

Disclosure statement

The author declares no conflict of interest.

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