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Research on the Application of BIM Technology in the Construction of Trans-Xijiang Extra-large Bridge

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Abstract: In recent years, with the development of information in the construction industry, BIM technology has become a tool applied in project management in the construction industry. As a special kind of architecture, bridge engineering should also fully grasp the opportunity of transformation brought by information technology to the industry. This paper takes the application of BIM technology in the construction of trans-Xijiang extra-large bridge as an example, From the model building, collision check, drawing optimization and coordination management, and other aspects, with complex nodes in large-scale bridge construction simulation and visualization clarificaiton, effective for schedule, cost control, and improve the efficiency and effectiveness of construction management, engineering for the construction and lean management, lean has a great effect on the development of bridge work.

Keywords: BIM Technology, Bridge Construction, Project Management

1. The Introduction

The concept of BIM (Building Information Modeling) originated in the United States and was first proposed by Chuck Eastman, professor of architecture and computer department at Georgia institute of technology [1]. Architectural information model, which is translated into Chinese, is the most concerned concept in the process of building industry information. At the beginning, BIM technology developed rapidly in the manufacturing industry. With more and more complex construction projects, the construction industry has higher and higher requirements on production efficiency, and some complex buildings also began to require BIM technology, such as bird's nest, water cube, Shanghai Disneyland and many other buildings [2]. As a special form of architectural structure, bridge has various forms, complex structural forms, and many members of opposite sex. In the construction process, there are some characteristics such as high risk, special construction technology, and high construction quality requirements [3]. The traditional construction technology cannot meet the needs of bridge engineering. Therefore, bridge engineering should also fully grasp the opportunity of industrial transformation brought by information technology and enjoy the improvement of production efficiency and economic benefits brought by the new production mode [4].

2. Project Background

Guangzhou Nansha port railway is located in the central region of the pearl river delta. The line starts from Heshan south station of Guangzhou-zhuhai railway and goes southeast through Heshan city, Jiangmen city, Foshan city and Zhongshan city to Nansha port district. The full section three of the new Nansha port railway station is part of Xijiang extra-large bridge, among which the cross-Xijiang cable-stayed bridge is the key and difficult project of this section. Xijiang extra-large bridge is located in Jiangmen city and spans the Xijiang river at the branch of ancient town (2×57.5+172.5+600+4×57.5)m mixed beam cable-stayed bridge is adopted. The total length of the bridge is 1118.7m, as shown in figure 1. Mainly prefabricated bridge construction, its transport to the scene to assembling, welding, bolt connection, and the relevant work, therefore the scantling design and production of the demand is higher, if not in conformity with the production of components, can only to production, this not only affect the construction progress, also will increase the cost of the construction process.

In order to ensure the smooth progress of construction, the project based on BIM technology project management mode, through 2d design drawing of bridge model is set up, and then optimize the design, application of BIM technology in the engineering construction stage, improve the ability of project planning, enhance the capacity of project process control, improve the quality of the construction design and efficiency, enhance the level of refinement management in different stages of the project [5].

Figure 1. *Rendering of the large bridge across Xijiang river.*

3. BIM Model Construction and Drawing Optimization

This project firstly builds the model according to the design construction drawing BIM software provided by the project team, and adds the corresponding parameter information to each component during the modeling process, so as to detect the conflict of reinforcement and joint in the component, and provide model support for construction simulation on the other hand.

3.1. Parametric and Informational Design of Models Based on Design Drawings

In the application of Revit software to build bridge model, the role of "family" is more prominent [6]. As a ribbon structure, the bridge has many similar components along its length direction, the appearance of these components, the general size is basically the same, only in the details of the size, the structure is slightly different. If you use 3D MAX, SU, CAD and other non-parametric software, you need to draw one by one, which requires a large amount of repeated labor and low efficiency. If there are complex special-shaped components, the reliability of the model will be compromised.

There are three types of anchoring blocks on the prestressed concrete beams of the middle side span of Xijiang extra-large bridge, including 27 types of class I anchoring blocks, 6 types of class II anchoring blocks and 3 types of class III anchoring blocks. By using the revit family tool, a basic anchor block template is created by setting parameters and correlation. All types of anchor blocks can be created by setting parameter values in their property information and modifying them, as shown in figure 2. If the structure or material of the anchor block needs to be modified in the later stage, there is no need to edit one by one, only the sample in the family file needs to be edited, and all components in this project using this modification family will be updated automatically.

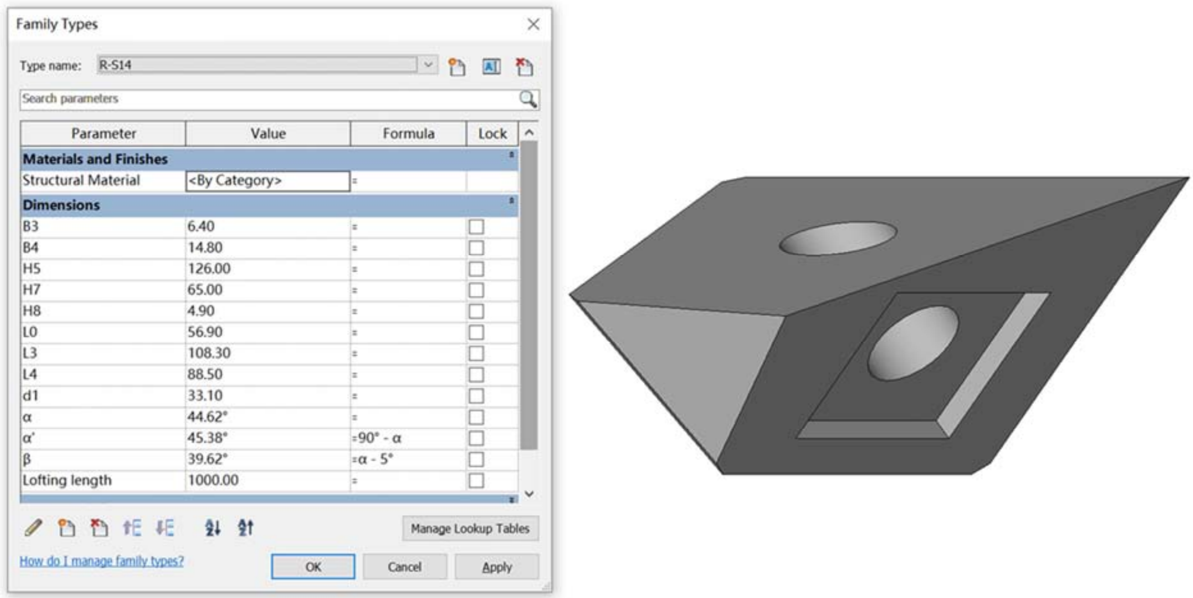

Figure 2. *Parametric model of anchor block.*

3.2. Collision Inspection and Design Optimization

For such a large-scale bridge project, its design is relatively complex, in order to meet the needs of the actual structure; it needs to involve a large number of components, especially the joints of components. In traditional two-dimensional design, these problems are mainly detected by designers' experience.

Due to the complexity of engineering projects, it is difficult to detect all the problems in the drawings by relying only on designers' experience. In the 3d BIM model of the bridge, each component has corresponding engineering parameters, which can drive the 3d model through various parameters. The structure of this cable-stayed bridge is relatively complex, and there are many embedded parts in construction. Therefore, conflicts are easy to occur in the design, and collisions of cable conduit, prestressed pipe, embedded parts and other spatial locations are often encountered. Based on the built model, collision simulation detection is conducted to analyze the defects in the design, so as to deal with them in advance, as shown in figure 3. According to the characteristics of the project, collision detection mainly includes the detection of the whole bridge and the detection of some components. The detection process is simple and convenient. The built model is imported into Navisworks (BIM software), which automatically conducts collision inspection and analysis [7]. After the completion of collision check, the system can automatically display the components or objects with collision conflicts and generate collision collision report, and can directly return to revit, locate the collision site, modify the model, save the modified changes and update them synchronously to Navisworks, greatly improving work efficiency. Before construction, the construction party will solve these components that need to be changed through communication with the designer, which will reduce the loss of materials and labor costs in the construction stage and save the construction time.

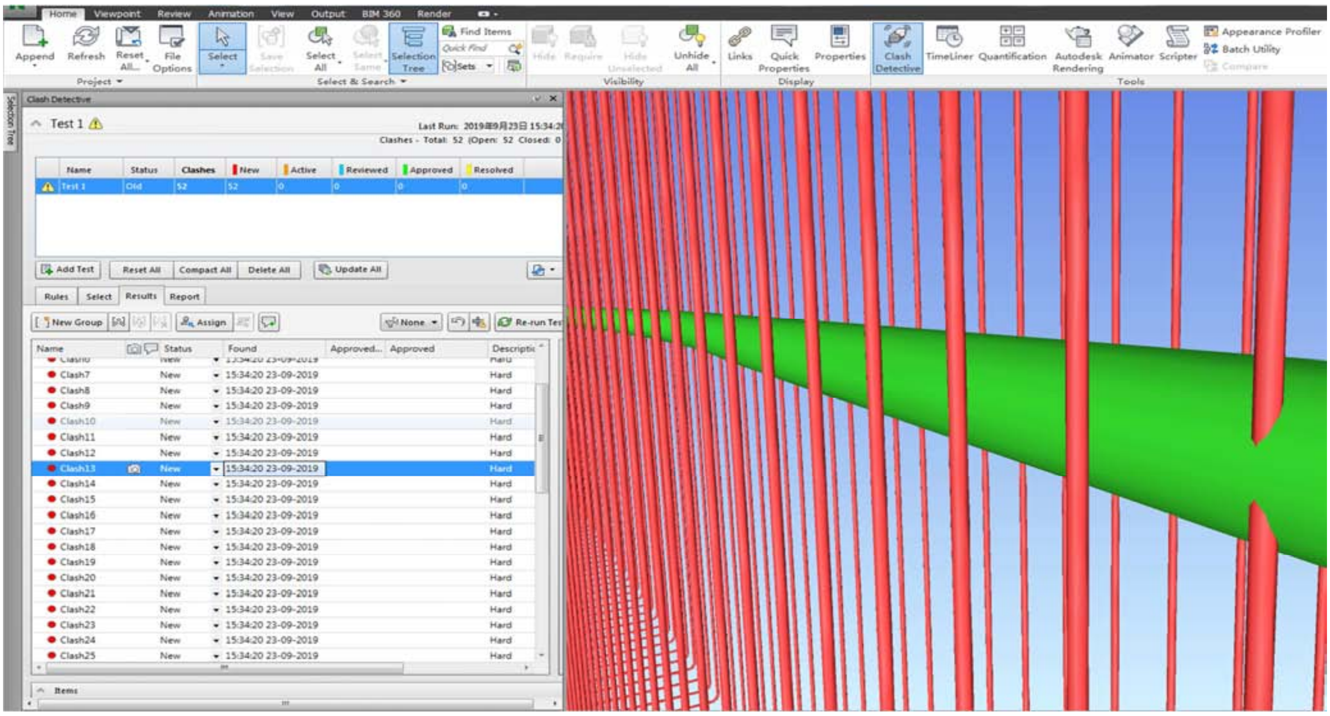

Figure 3. Collision inspection of bellows and steel bars.

4. Construction Management Optimization Based on BIM Technology

Bridge construction is a complex and dynamic process. With the continuous progress of bridge construction, the scale of the project is increasing, and its complexity is also increasing, which means that the difficulty of construction project management will be more and more difficult. At present, the bridge construction schedule is arranged by project, which is mainly expressed by Numbers and words, and lacks visualization of graphics. These factors will make it impossible for the construction personnel to clearly understand the construction schedule and the complicated relationship between various components [8]. Project will BIM model combined with the project, then the project the project item name of the one to one correspondence with model artifacts attribute names, derived after the construction progress of using Naviswork visualization simulation, through its 4D (3D model and project development time) simulation, animation features help to demonstrate the design intent, simulation of construction process, thus deepening project understanding, enhance predictability, improve the efficiency of collaboration between the project team, as shown in figure 4.

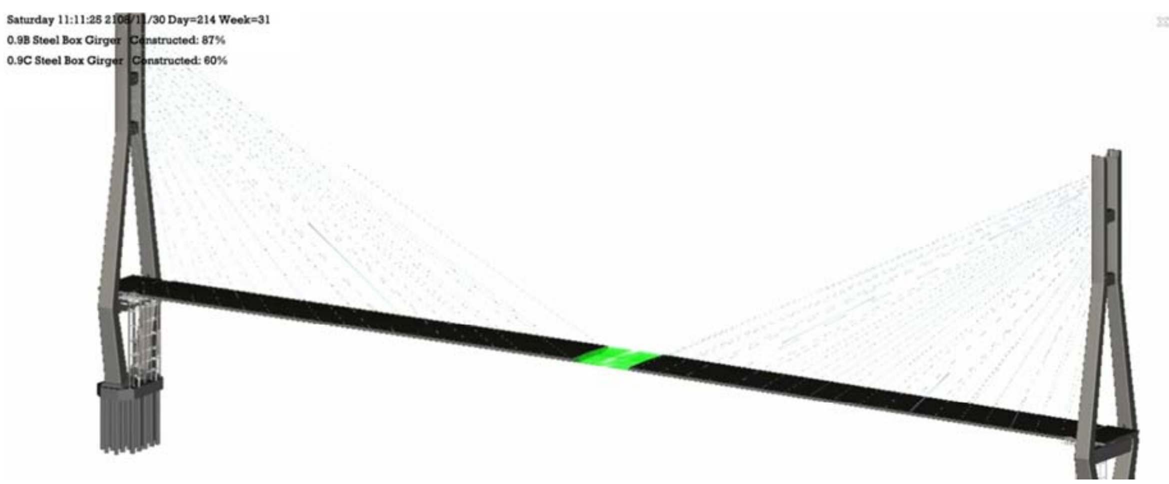

Figure 4. *4D construction simulation process.*

4.1. Simulation and Optimization of Construction Process

In this project, the construction simulation shall first determine the simulation object or content, formulate a model establishment plan for the simulation content, and simulate the nodes, processes or schedule arrangement with animation. Project managers and BIM modelers shall jointly discover and solve problems. In this process, the reasonable construction process is mainly adjusted based on the Suggestions of project personnel, and the BIM model is updated until the best construction plan is finally determined. The process is shown in figure 5.

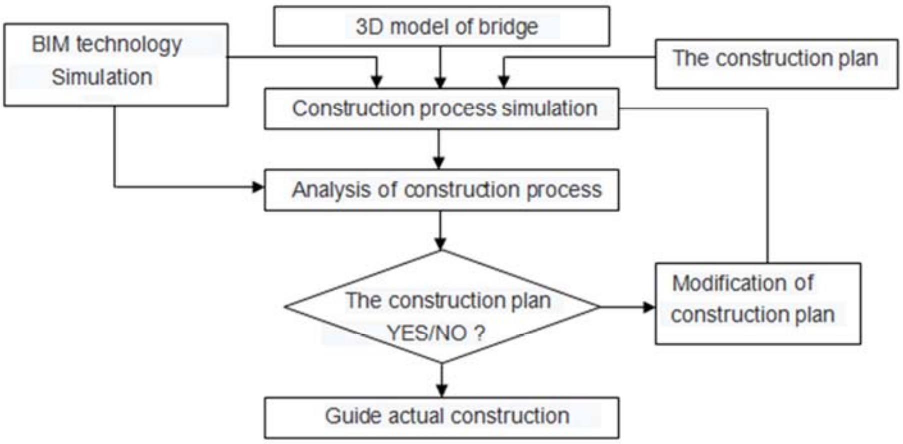

Figure 5. *Bridge construction simulation process based on BIM technology.*

For example, the steel-mixed joint section of this project is the key and difficult control process of the entire cable-stayed bridge. The mixed section has dense reinforcement bars, PBL shear keys and prestressed pipes, which cause great interference in the cross-construction. The steel grid space is extremely narrow, the installation of PBL shear key is complicated, and the reinforcement of transverse girder is dense, which is difficult to cross construction organization. Among them, the total amount of steel bars in a single steel grid chamber is 484, the total amount of steel bars in the transverse girder is 1584, a total of 139PBL shear bars and 67 prestressing tendons. Reinforcement quantity, the space is narrow, the reinforcing bar colligation a lot of difficulties, due to the order of the binding problem, causing many steel bar could not tie, can only be carried out on the first tie bar cutting, in the back, after the completion of steel binding again for cutting steel welding, which largely wasted materials, manpower, also has negative influence on the mechanical properties of steel, complex construction technology, strict construction condition, construction difficulties and construction experience that we still lack.

It is difficult to make a real-time comparison between the scheme prepared under the traditional two-dimensional drawing mode and the actual situation. The traditional CAD plan is configured in the complex construction technology, which cannot be visualized. These factors make it impossible to clearly describe the complex relationship between the construction process and various work, and to completely and clearly express the whole process of mixed section construction.

Through BIM technology, the whole mixed section adopts the creation of full 3D model, carries out visual analysis, 3D construction space simulation and collision inspection [9]. The gap and irrationality between the drawing design and the actual construction are found through comparison, so as to quickly foresee problems in advance, timely communicate and solve problems, and finally optimize the construction plan, which is conducive to the overall control of the risk in the construction process of the mixed section, as shown in figure 6.

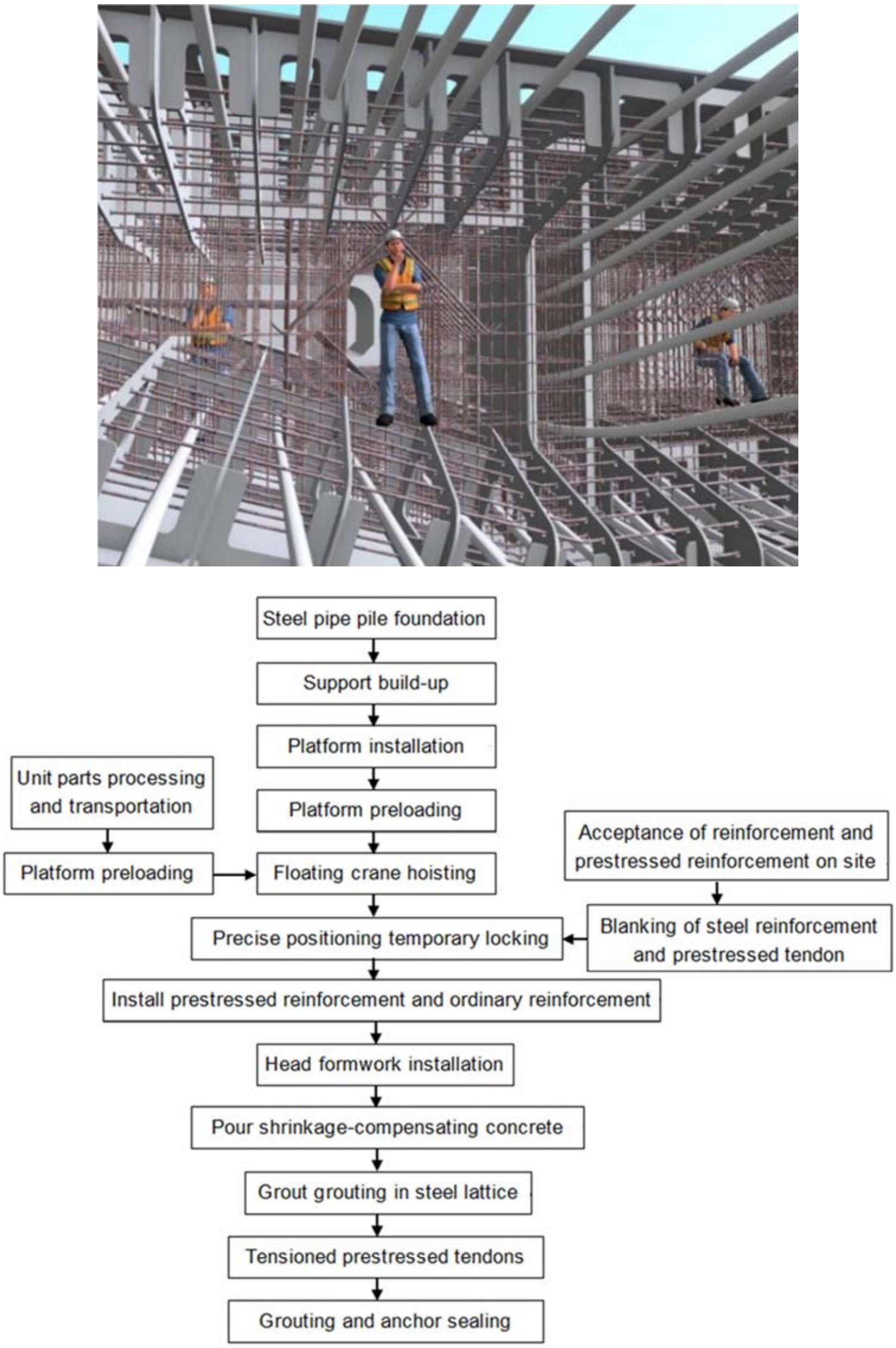

Figure 6. *Comparison between traditional construction process and BIM construction technology model diagram.*

4.2. BIM Technology-Based Collaborative Project Management

The construction of bridge engineering is a complex and comprehensive large-scale construction project, which generally involves various complicated geographical environments, resulting in more complicated construction. Traditional project management system based on 2D as the main tool and using the method of project management, all the contact way of the participants in the form of series, presents the status of the independent, the stages of project, each project information in the form of different dispersion exists, the transmission of information asymmetry often happen, a lot of inconvenience to the project information management [10]. These disadvantages in two-dimensional engineering project management reduce the efficiency of engineering project management, restrict the development of engineering project management, and bring inconvenience to the information management of the construction industry.

Based on BIM technology engineering project information management mode, the lack of coordination between the majors in traditional two-dimensional design is optimized. In the construction process of the project, the important parameter data or information involved in the construction schedule, project cost, safety management, pipeline collision and other issues can also be simulated to ensure the dynamic control and management of the whole project. It can also improve the management efficiency and reduce the problems in management. It can discover and solve the possible problems in the bridge construction process in advance, which changes the traditional management mode, that is, from the "passive management" when the problems occur to the "active management" when the problems are discovered in advance, so as to reduce the occurrence of construction problems and simplify the construction site management [11].

4.3. Visualization Disclosure Based on BIM Technology

Traditional field disclosure is mainly oral and graphic drawing disclosure, which is neither visual nor intuitive. There are also problems in the communication between construction personnel and field technicians, which may lead to unclear understanding of the drawings or misunderstanding of the field operation personnel, thus leading to various errors in construction [12].

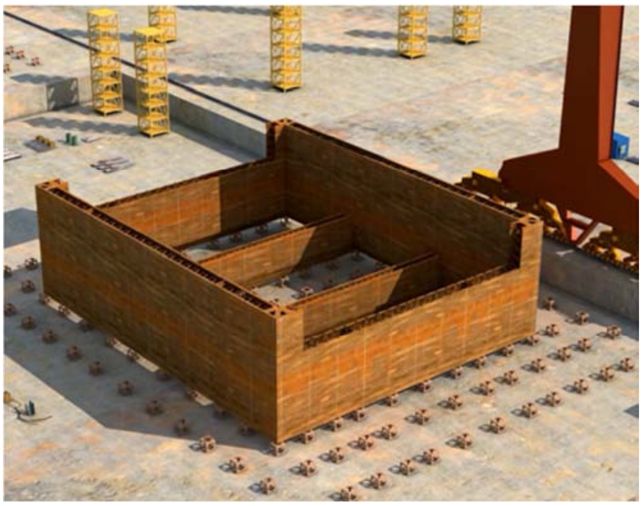

Figure 7. *Cofferdam assembled in the factory dock as a whole.*

In the construction process of this project, through the three-dimensional simulation of the construction scheme, the construction operators are given a visual disclosure, so as to minimize the construction difficulty and ensure the construction quality and safety. For example, the design, manufacture and construction of 156# double-wall steel cofferdam is a key project in this project. The plane size of the main pier double-wall steel cofferdam is 49.1m×41.2m, divided into two sections, the bottom section is 15.4m high, the top section is 10.6m high, and the total weight is about 2038.4t. Its large volume, large tonnage and high positioning accuracy requirements determine the difficulty. And cofferdam sinking positioning process, high precision, large construction difficulty, once the error will lead to serious consequences, according to the situation of the construction process of simulation, and visualization of disclosure in the form of animation, let the technical personnel for cofferdam construction process with intuitive clear understanding, predictable risk source, completes the safety, ensure smooth sinking location, as shown in figures 7, 8.

Figure 8. *Cofferdam transportation form.*

5. The Conclusion

China's bridge industry is developing rapidly at present. In order to improve construction efficiency and ensure engineering quality, most bridge components have been prefabricated in factories and transported to the site with large equipment for high-precision assembly. In this project and other large steel anchor beam, steel girder components combined with BIM model, adopt the factory prefabrication, using the 4 d construction simulation technique to the working condition of high precision test, it is concluded that the reasonable size of the prefabricated information, a process in place in the factory, reduce the negative influences to the site construction environment, the construction level, assure the construction smoothly, shorten the construction time for the homework [13]. According to previous construction experience, if all prefabricated parts are processed directly in accordance with the design drawings, cutting and repairing may occur due to accumulation of errors, control accuracy and other factors during on-site installation. Therefore, the use of BIM technology enables the bridge construction unit to control the construction progress and organize the construction scientifically and effectively [14]. Overall or local model collision can effectively avoid unexpected errors in construction and provide effective help. It is believed that with the continuous maturity and development of BIM technology, the application of BIM technology in bridge engineering will be more and more extensive, so as to improve its engineering quality, work efficiency and management level, It plays a great role in promoting the development of the whole engineering technology [15].

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References

[1] He qinghua, Qian lili, Duan Yunfeng, Li yongkui. Current situation and obstacles of BIM application at home and abroad [J]. Journal of engineering management, 2012, 26 (01): 12-16.

[2] Li jiulin, Zhang jianping, Ma zhiliang, Wang dayong, Lu wei. National stadium (bird's nest) general contract construction information management [J]. Construction technology, 2013, 44 (10): 874-876.

[3] Du shibo. Research and application of construction control technology of long-span welded steel box girder cable-stayed bridge [J]. Traffic world, 2017 (Z1): 148-149.

[4] Wang meng, li junhua. Application of BIM technology in bridge construction stage [J]. Highway traffic technology (applied technology edition), 2018, 14 (10): 61-64.

[5] Zhao wei, zhang shenglin, yan zhenhai, pingtang bridge BIM construction management research [J]. Highway, 2019 (7): 178-181.

[6] Sha mingqin, research on parametric modeling and secondary development of bridge engineering based on BIM technology [D], east China jiaotong university, 2019.6.

[7] Qin honglei, application of BIM based bridge engineering information technology [D], taiyuan university of technology, 2019.6.

[8] Wang shubin, zhao li, application of BIM technology in project management [J]. China construction 2019 (3): 50-51.

[9] Wang yingbin, li guohua, wang haifeng, zheng wan railway fengjie meixi river double line bridge BIM comprehensive application [J]. Civil and architectural engineering information technology, 2018, (5): 60-66.

[10] He jia, Chen le Collaborative management of EPC project [J]. China construction informatization, 2019 (8): 68-69. Zhu jiajia, Tan fei, Zhou bin. Research on BIM-based project management process, journal of three gorges university (natural science edition) [J]. 2015.4: 95-97.

[11] Zhu jiajia, Tan fei, Zhou bin. Research on BIM-based project management process, journal of three gorges university (natural science edition) [J]. 2015.4: 95-97.

[12] Shi ruiying, he hongbo, zhang xianlin, application research of BIM technology in construction of yongchuan Yangtze river bridge [J]. Journal of graphics, 2016, (4): 556-560.

[13] Qu pu, Zhang dongsheng. Key technology analysis of closure control of long-span continuous rigid frame bridge [J], highway traffic science and technology (application technology edition), (11): 5-7.

[14] Liu yanhong. Application of BIM technology in railway bridge construction [J], technology research (railway technology innovation), (3): 47-50.

[15] Wang zengxian, application and advantages of BIM technology in bridge construction stage [J]. Chinese and foreign architecture, 2019, (6): 248-250.