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Research on the Specific Applications of BIM Technology in Bridge Construction

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Abstract: *BIM technology is one of the most widely used technologies in the construction industry because of its apparent advantages. The application of BIM technology in bridge construction will give full play to the advantages of virtualization analysis and visual interpretation of BIM technology, so that the construction personnel can clarify and then solve the construction problems, and finally effectively improve the quality and efficiency of bridge construction. The construction of a building information model supported by BIM technology connects bridge construction, design, operation, maintenance, and other stages in series, solves the problem of collision inspection, and realizes the automatic statistics of engineering quantities. This work mainly analyzed the specific application of BIM technology in bridge construction, clarified its application advantages and application manifestations, and put forward some application suggestions.*

Keywords: *Bridge construction; BIM technology; Application cases; Suggestions*

1. Introduction

For the construction of bridge engineering projects, the rational use of BIM technology will effectively improve the productivity and quality of bridge construction. Through grasping bridge construction information, BIM technology constructs a building information model to provide suggestions on collaborative work and guidance on parameter adjustment for construction management. This measure optimizes the design layout, coordinates project management, and reduces construction costs while cutting down the rework rate.

2. Overview of BIM Technology

BIM technology was first introduced in the United States in the 1970s and has been widely used in the construction industry since the 21st century. In the construction industry, the most important application result of BIM technology is the construction of a building information model. Based on 3D digital technology, BIM technology enhances information management and drives the adequate storage and flexible exchange of information utilizing interactive movement, which creates good conditions for collaborative operations [1]. BIM technology supports the digital expression of building entities and functional information, which triggered the revolution in the construction industry and brought steady improvement in construction quality. At present, the application of BIM technology in the construction industry is very urgent. For one thing, the characteristics of bridge engineering projects increase the urgency of the promotion and application of BIM technology; for another, the advantages of BIM technology play a driving role in its promotion of the construction industry. In the current bridge engineering construction, BIM technology should be fully used to improve construction quality and efficiency.

3. Construction Characteristics of Bridge Engineering

Bridge engineering construction is different from general construction projects and has its own distinctive characteristics. The most significant difference is that engineering construction is more complicated, reflected in three aspects. First, the bridge project is large in scale. Large scale not only refers to the large volume and structure of bridge engineering but also manifests in the large scale of specific components, which increases the difficulty of bridge engineering construction. Therefore, construction and management personnel should coordinate all the elements, realize the characteristics of the project on a large scale, and avoid the situation that project quality is substandard due to the influence

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of various factors [2]. Additionally, the construction is very complicated. From the perspective of the overall structure of a bridge engineering project, the structure is more complex both in design and component construction. For some traditional casting projects of bridge engineering, if their casting effect is not ideal, it is easy to affect the stability and security of bridge engineering. Finally, the construction environment is variable. The construction environment has an evident influence on bridge engineering construction. Adverse environmental factors will lead to construction quality problems and construction schedule delays, thus increasing construction safety risks. In order to guarantee bridge engineering construction complete success, new construction management thinking or technology should be introduced, and BIM technology is just the ideal choice.

4. Application Advantages of BIM technology in Bridge Construction

The introduction of BIM technology in bridge engineering projects will significantly improve the effectiveness of construction management and ensure the quality of bridge engineering. The application advantages of BIM technology are mainly reflected in the following three aspects.

4.1. Ensure information integrity

BIM technology has outstanding information integrity advantages. When it is introduced into bridge engineering projects, the specific types of components and related components in bridge engineering projects can be comprehensively analyzed and deeply interpreted. In this way, it can make full use of effective data information to provide cooperative operation guidance and practical management control assistance for construction.

4.2. Strong model correlation

The application advantages of BIM technology are also reflected in the vital information correlation attribute of the constructed model, which also means that within the building information model structure, the components are more closely related, and the corresponding mechanism can be presented in detail [3]. According to the relevance of the information, personnel can optimize the project's design relying on the effect of the correlation, guide the construction, and bring the ideal construction effect.

4.3. Full model visualization

Introducing BIM technology in bridge engineering projects can realize visual analysis and virtual verification. Through accurately grasping the critical points of construction and clarifying the key links of construction, bridge project designers and construction personnel can realize detailed collision inspection and intuitive visual analysis so that the construction management will be more standard and normative, the human-caused error in construction and management will be reduced, and the final effect of construction will be guaranteed.

5. Specific Application of BIM Technology in Bridge Construction

5.1. Optimize the construction process with scientific simulation

The introduction of BIM technology in the construction of bridge engineering projects can give full play to its 4D simulation function and scientifically compile the construction organization plan. Based on the scientific construction organization plan, it can strictly control the construction progress and coordinate the construction site resources, so as to achieve the optimal allocation of resources, and achieve management from point to area. In order to ensure the construction quality and construction progress of the bridge engineering project, and make the economic benefits of the project more prominent, management personnel can use BIM technology to start the simulation system. Based on this, the bridge design is closely combined with the 3D model, and the construction link and construction process are simulated, so that the construction personnel can accurately understand the construction structure, carefully analyze the scientific construction process, and the rationality of component installation, and avoid frequent rework. In construction, the process management advantage of BIM technology can help personnel find problems and adjust in time, so as to facilitate the steady progress of the construction.

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5.2. Increase the possibility of collaboration with information sharing

The bridge construction system is complex, and there are many participants in the project construction, which needs to strengthen the cooperation of the participants. However, the premise of collaboration is high-quality information sharing. In this case, introducing BIM technology can enhance the connection between design units, construction units, and material suppliers so that they can always reach an agreement in the bridge construction, avoid poor coordination efficiency caused by less communication, and eradicate construction lagging problems. The high degree of information sharing increases the possibility of cooperation, and construction cost control is also ideal. Specifically, by sorting out the contents involved in bridge engineering construction and uploading them to the BIM information-sharing platform, each project participant can learn about the project information with the help of the project management platform. At the same time, they are able to retrieve data, adjust data information, and share with each other within their information processing authority [4]. The information-sharing function of BIM technology enables a higher degree of cooperation between various subjects, and can realize the unity of objective management, cost management, and quality management in the process of bridge construction, which is of outstanding significance for bridge construction.

5.3. Optimize construction project management through dynamic analysis

Bridge engineering construction is a dynamic process, so it is necessary to manage the project with dynamic thinking. Bridge construction involves a lot of structural components, and the construction process is complex; therefore, the construction process is occasionally adjusted. The introduction of BIM technology in the construction of bridge engineering can scientifically simulate the geological environment of the construction area, guide the selection of scientific construction sites and drilling rig equipment, and lay the foundation for early construction. BIM technology allows managers to interpret the construction process with dynamic thinking, clarify the contents to be adjusted in the construction drawings, and optimize the construction in time. In particular, BIM technology has the characteristics of interactive mode, which can compare the azimuth angle, elevation coordinates, and various models obtained through the actual measurement with the information content to ensure the integrity and accuracy of the data. At each stage of bridge engineering construction, each part has exact data reference, and then the construction operation will be more standardized and smooth, and construction materials and cost control will be more scientific. In general, BIM technology realizes the whole process of bridge construction management.

5.4. 3D modeling integration drives construction progress management

The application of BIM technology in bridge construction is also reflected in the construction progress management driven by 3D modeling integration. The 3D model can be used for integrated analysis of construction planning, and time can be used as the base latitude for construction simulation. As a unit, the construction time can combine the simulated construction with the actual environment of the construction site, and then guide the reasonable adjustment of the construction progress, and increase the rationality of the project development. Some difficulties and key problems restricting the progress of construction can also be simulated and analyzed visually by BIM technology, and the construction operation space can be highly shared. The flexible configuration of various equipment in the construction can make the effect of overall management significantly better than a single project, and greatly reduce the management cycle.

6. Case Analysis of BIM Technology Application in Bridge Construction

6.1. Case introduction

The Baijusi Yangtze River Bridge project is one of the key Public-Private Partnership (PPP) projects in Chongqing. The project starts at Chenjiage Interchange in the west and ends at Taiyanggang Interchange in Banan District in the east. The bridge is 1,622 meters long, and the main line is eight lanes in both directions, which spans 660 meters with a double tower and cable-stayed bridge. The upper layer of the bridge is for road traffic, and the lower layer is for rail traffic, and pedestrian access roads are set on both sides. In this construction, BIM technology has been successfully used to solve design and construction problems, and the ideal construction effect has been achieved.

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6.2. Specific application

The overall plan for the BIM application was formulated before the project, and the responsibilities of each participant were also defined. All parties to the project shall comply with the BIM implementation guidelines and relevant standards to standardize the BIM workflow. Moreover, it is necessary to apply BIM technology according to the requirements of the contract, and deliver BIM results consistent with the design drawings. BIM technology visualizes construction plans to help troubleshoot problems and optimize adjustments prior to construction. What is more, the BIM information model can ensure the continuity of BIM information. Clarifying the responsibilities of each party and the specific workflow will assist in laying the foundation for the subsequent application.

First, build a BIM library. It is the first step of basic modeling work to establish the component library of different specialties and types. The library components parameterization greatly improves the efficiency and accuracy of modeling. Second, accurate calculation. The initial earthwork calculation and double-check of Civil3D can solve the problem of the large numerical gap caused by design mistakes. Third, focus on the construction of the main bridge. Located in the main urban area, the main bridge spans the Yangtze River, which requires high requirements for environmental protection during the construction period. BIM+GIS technology can be used to collect the site situation through regular photography of UAV, and the real scene modeling technology can integrate the structural BIM model to form the sand table of the real scene, which plays a good auxiliary role in the selection of the construction road. Fourth, focus on the construction of the cable tower. The cable tower is 236 meters high, and the linear shape is significantly affected by temperature, sunshine, tower crane attachment and other factors, so it is difficult to control the linear shape construction. The coordinate value can be directly derived from the 3D model and compared with the measured values in real-time for timely adjustment and accurate installation. The cable tower is a water drop-shaped structure, and the lower tower column and beam are round curves, so the overall linear shape is complex. Measures such as reasonable division of tower segments, optimization of template design and block in a 3D model environment, 3D template design, and virtual pre-assembly can control the accuracy of the template processing and ensure the quality of the template [5]. The cable tower is densely reinforced and arranged. The conflict between cable tower embedded pipe and ordinary reinforcement is detected using NavisWorks, and 62 main collision points are found to be arranged and optimized. Fifth, the construction of steel truss beam structure. The structure form of steel truss beam is complex, the member plate thickness is large, and the linear relationship is complex, so the production precision requirement is high. Through the simulation of pre-assembly, the problem of matching the accuracy of the rod joint is found in time. Sixth, it is necessary to show the detailed drawing to construction workers, so as to ensure the appropriate stitching. By using BIM+ virtual assembly technology, the environment of the model can be changed, and the accuracy of the steel beam closing can be controlled. Seventh, according to the characteristics of the river flow direction, a special anti-collision design is carried out for temporary structures during the construction period. In addition, the traffic dredging during construction is simulated and optimized, and the walking route of large equipment is simulated to ensure the feasibility of the dredging plan and the fluency of the site construction. Eighth, the precast beam should realize industrialized production and on-site assembly. For the standardized model of components, the 3D simulation system supported by BIM technology is used to deepen the design, guide the on-site production, and improve efficiency and accuracy.

6.3. Benefit analysis

Based on the BIM bridge reinforcement calculation and optimization of the material cutting, the reinforcement material control ability is greatly strengthened, and the material waste is reduced. Considering only the steel bar of the whole bridge pile foundation, the direct cost saving is 450,000 yuan. The project inspects 529 collision points, deepens the design, and reduces the rework rate of site construction to more than 70% according to the major and difficult points of project construction, reducing the cost loss of 3.5 million yuan and saving a total of 35 days of construction. In terms of large-volume earthwork calculation, the data is real and reliable, proving the design institute's design error. The engineering quantity is about 100,000 square meters. This bridge construction project applies BIM+ smart site platform, and really implements BIM technology into the physical project through the combination of theory and practice, which once again verifies the advantages of BIM technology in bridge construction. At the same time, various innovative applications of BIM have been unanimously recognized by the owners and external units, which has improved the core competitiveness of the corporate society.

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7. Conclusions

The introduction of BIM technology in bridge construction will give various support to construction and management and drive the steady development of the bridge construction industry. Then, it is necessary to further study BIM technology, explore more of its application value, and clarify its application points in bridge construction so as to truly play the technical advantages and improve the construction efficiency and quality of bridge engineering. BIM technology should be promoted nationwide so that BIM technology can be truly integrated into bridge construction, solve technical problems, eliminate project management confusion, and bring about changes in traditional construction and management.

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