Transactions on Engineering and Technology Research
ISSN: 2960-1797, eISSN: 2960-2246 | Volume 4
ACEGE 2024

Application and Prospect Analysis of BIM in Bridge Engineering

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Abstract. Building Information Modelling (BIM) technology, has been widely used and promoted in the field of construction and bridge engineering in recent years. This paper mainly discusses the application of BIM technology in bridge engineering and analyzes its prospects. First, this paper introduces the basic concepts and characteristics of BIM technology, including its advantages of visualization, coordination, simulation, optimization and high efficiency. Then, the application and core advantages of BIM technology in the process of bridge engineering design and construction are elaborated in detail. In the design phase, BIM technology can create a three-dimensional (3D) model of the bridge, improve the visualization and collaboration of the design, and reduce design errors and conflicts. During the construction phase, BIM technology can help the construction team to carry out collision checking, construction simulation and schedule control, and improve construction efficiency and quality. The application of BIM technology can improve the design and construction quality of bridge engineering, reduce engineering changes and costs, and improve the efficiency and level of project management. Finally, this paper proposes that the future development prospect of BIM technology in bridge engineering is optimistic, and relevant technical personnel should continue to strive to promote the application and development of BIM technology, and make greater contributions to the digitalization and intelligence of bridge engineering.

Keywords: BIM Technology; Bridge Engineering; Application Analysis.

1. Introduction

With the continuous progress of science and technology and the rapid development of society, bridge engineering, as an important part of the world's transportation field, is facing higher and higher requirements for its construction quality and efficiency [1]. In this context, Building Information Modeling (BIM) technology has emerged and shown great potential in the field of bridge engineering. BIM technology is a digital approach to building design and management, which realizes the information management of the whole life cycle of the project through the digital description and simulation of the physical and functional characteristics of the project [2]. It enables full lifecycle management of a project from design to construction to operation by creating a detailed 3D model of the project and integrating all relevant information about the construction project. In bridge engineering, the application of BIM technology can improve design quality, optimize the construction process, reduce operation and maintenance costs, and improve the overall management efficiency of the project [1].

Through the policy promotion of governments and the active exploration of the industry, the application of BIM technology in bridge engineering has achieved remarkable results. In practice, it has been found that the application of BIM technology in bridge engineering can not only improve the design level of the project and ensure the safety of construction, but also effectively shorten the project cycle and improve the project efficiency. However, the application of BIM technology in bridge engineering still faces some challenges, such as the application of technical standards, the efficient construction of three-dimensional (3D) information models, and the effective development of BIM applications in the construction stage [3].

This paper aims to discuss the application value and future development direction of BIM technology in bridge engineering, deeply analyze the specific application of BIM technology in the design and

construction of bridge engineering, and discuss the role and effect of BIM technology in solving practical problems in bridge engineering based on actual case practice. At the same time, this paper also studies on the challenges and limitations of BIM technology in bridge engineering, and analyzes the application prospect of BIM technology in the field of bridge engineering, in order to provide theoretical support and practical reference for promoting the in-depth application and development of BIM technology in the field of bridge engineering.

2. BIM Technology

2.1. Definition of BIM Technology

BIM technology is a digital approach to building design and construction management. By building a 3D model of a building or infrastructure, it integrates a variety of relevant information, including physical, functional, structural, cost, and other aspects of the data. This technology aims to achieve full life cycle management from design to construction, operation and maintenance, improve the construction efficiency and quality of buildings or infrastructure, reduce costs, and provide better decision support and visualization effects. BIM technology has been widely used in the construction and infrastructure industry and is gradually expanding to other fields [3].

2.2. Composition of BIM Technology

According to the actual application, BIM technology is mainly composed of CAD design module, construction animation simulation module, terrain processing module, and building structure modeling module, and the functions used vary from module to module [4].

(1) CAD design module

The module consists of 3D CAD software and 2D aided design software. 2D software is responsible for editing and saving blueprints. The 3D software is compatible with files in common formats such as IGS and can perform 3D structural design tasks.

(2) Construction animation simulation module

The module integrates information such as design data and graphic information and is responsible for importing flat files such as images and blueprints into the software. It then outputs an animated video in a specific format to visually present the design of the project and simulate the construction process [3].

(3) Terrain processing module

The measurement data such as line lines are imported into Civil 3D software, and the terrain curve information and drawing model are constructed according to these data. The information model is then combined with geometric and sectional views to form a dynamic 3D model of the project site together with the original model.

(4) Building structure modeling module

The module consists of the Structural Engineering Module, the Architectural Design Module, and the MEP Engineering Design Module, and at the same time, through the combination of Revit and Civil software, the construction status and engineering design effect of each time node can be expressed in three dimensions [5].

2.3. The Core Advantages of BIM Technology

There are many advantages of BIM technology. These core advantages of BIM technology make it widely used in bridge engineering design, and play an important role in improving work efficiency, reducing costs, and improving design quality [6].

(1) Visualization

BIM technology can create a three-dimensional visual model of the bridge structure, so that the designer can intuitively see the appearance, structure and internal layout of the bridge, which can make it easier for the designer to find structural problems and correct the plan, so as to avoid obstacles in the subsequent construction process. At the same time, the 3D view can also enable non-professionals, such as project managers, investors, and government officials, to clearly see the effect of the design, and improve the efficiency of design communication and decision-making [3].

(2) Model information management

BIM model is not only a graphical model, it also contains a wealth of attribute information and behavioral information, such as material properties, equipment performance, cost budget, etc., to support project management and decision-making. The application of BIM technology can complete the integration and sharing of information, realize the efficient use of information data and the digital control of project costs, and provide an accurate and reliable information management platform for bridge engineering projects.

(3) Quantity calculation and cost control

BIM can accurately calculate the quantity of work, help reduce the error of cost estimation, and optimize the construction plan and reduce cost waste by simulating the construction process.

(4) Design optimization

In the design stage, BIM can carry out structural analysis and optimize the design, and select the best design scheme by simulating different design schemes to improve the design quality.

(5) Synergy

By applying BIM technology, members of various technical groups can integrate their data and solutions on a single platform. And the design is based on unified model data, so as to avoid design conflicts and other problems, and improve design efficiency and quality [7].

(6) High efficiency

The use of BIN technology for the simulation and planning of the construction plan replaces the traditional manual drawing, all operations are completed on the computer, and the data is calculated by the computer, saving time and improving accuracy.

3. The Application of BIM Technology in Bridge Engineering Design and Construction

3.1. Changqing Yellow River Bridge

The Changqing Yellow River Bridge (Fig. 1) is an important part of the Jinan-Zhengzhou high-speed railway, which spans the Yellow River and connects Jinan City in Shandong Province and Zhengzhou City in Henan Province. With a total length of about 5.15 kilometers, the bridge is the only major and difficult project on the entire line of the Jizheng high-speed railway. It is the first high-speed railway bridge in China to use a reinforced concrete structure to cross the lower reaches of the Yellow River, and it is also the longest and largest prestressed reinforced concrete bridge in China.

Figure 1. Changqing Yellow River Bridge [8]

In the design process, the BIM technical team integrated the computer graphics theory, the data structure of BIM software and its development framework with the professional railway bridge design process based on Dassault's 3D bridge design system, and developed a bridge BIM design system with the design functions of simply supported beams, continuous beams, piers and foundations. This reduces the difficulty of modeling and reduces the workload compared to existing BIM commercial software. During the BIM production project, the technical team used Dassault software's catalog feature to efficiently manage template design results. Comprehensively use the 3D geometric modeling functions such as equal cross-section solids, multi-section solids, extrusion, shearing, Boolean operations to create a refined BIM model of simply supported beams, call the assembly pattern function of Dassault software, select the geometric sets of simply supported beam templates and loading coordinate systems respectively, and finally complete the batch instantiation of various simply supported beams, and use BIM technology to grasp material properties, equipment performance, cost budgets, etc., which provides support for project management and decision-making. During the design process, the BIM technical team selected the best solution by simulating a variety of different design solutions, which improved the design quality. In this project, the BIM technical team used a mixture of BIM technology and other technologies, such as bridge 4D simulation technology and 3D GIS technology, to a certain extent, alleviating the difficult problem of modeling existing BIM commercial software, improving design efficiency and accuracy, and achieving good results [8].

3.2. Weihe Bridge

As the first steel truss girder bridge built by public rail in Northwest China, the Weihe Bridge is in the form of a stiffened continuous steel truss girder bridge on the curve, with a main span length of 300m and a joint length of 1412 m, with a steel structure of 132,000 tons and 10,526 components. The amount of engineering ranks first among similar bridges in China. In the process of engineering construction, there are three main difficulties: the large amount of steel structure engineering, the difficulty of jacking construction, and the large construction depth of deep buried cushion cap and steel pipe pile cofferdam.

In order to solve these problems, the BIM technical team used Dynamo to realize procedural modeling on the basis of Revit modeling, which solved the problem of difficult modeling of special-shaped and curved structures. Instead of using the usual Revit modeling method, it avoids the time-consuming and inefficient difficulty. Fig. 2 shows Weihe Bridge BIM technical renderings. With the help of the three-dimensional reality model, the inconvenient impact of the Weihe River water area on the construction of the bridge structure is evaluated, and the advantages of platform engineering calculation are used to select the appropriate size area on the real scene model for earthwork simulation river filling, and the amount of earthwork filled in the river is accurately calculated according to the floor design elevation and the perennial river bottom elevation, which provides a strong basis for the project engineering calculation. The amount of engineering calculations is reduced, and the simulation of the construction process also reduces the cost waste. As one of the main materials of engineering structures, steel bars occupy a considerable proportion in the cost budget. The project technicians use BIM technology to carry out reinforcing bar resampling modeling, realize the fine BIM management of reinforcing bars, reasonable blanking, reduce rebar waste, and save construction costs. At the same time, BIM technology is used to plan the construction site as a whole, and reasonable deployment of water, electricity, green construction, and road signs and signal lights is carried out, which improves environmental adaptability and reduces the problems faced by the construction team in the specific construction process [9].

Figure 2. Weihe Bridge BIM technical renderings [9]

4. Challenges and Solutions of BIM Technology in Bridge Engineering Applications

4.1. Challenges

The application of BIM technology in bridge engineering has become more and more common, but it also faces the following problems:

(1) The breadth and depth of technology application are insufficient. The scope and depth of the application of BIM technology in bridge engineering need to be further expanded and deepened. Due to the complexity of the bridge structure, BIM is extremely difficult and the lack of suitable plug-ins and tools makes it difficult to apply the technology.

(2) Uniform standards and norms are lacking. The standardization of BIM technology has not been fully addressed. The compatibility between different software, the inconsistency of data exchange and sharing standards, all bring difficulties to the BIM application of bridge engineering.

(3) Modeling is difficult. The complexity of bridge engineering structures makes BIM modeling difficult. The many components and systems in bridge engineering and the complex interaction of each other require BIM software to be highly adaptable and capable of handling complex structures.

(4) Technical training and education are inadequate. Proficiency in BIM technology requires strong knowledge and practical experience in related fields, and bridge engineering and technical personnel may lack sufficient BIM technology training and education, which affects the effective application and promotion of BIM technology [10].

4.2. Solutions

(1) Strengthening technology research and development

By strengthening the research and development of BIM-related software and tools, it will improve its modeling capabilities for complex bridge structures, simplify the modeling process, and provide more plug-ins and tools to meet the special needs of bridge engineering.

(2) Formulating unified standards and norms

It is necessary to promote the establishment of unified BIM technology and data standards in the industry to ensure compatibility and data exchange efficiency between different software and platforms.

(3) Expanding human resource development

It is necessary to increase the BIM technology training and education for bridge engineering technicians to improve their grasp and application ability of BIM technology.

(4) Enhancing technological innovation

Enterprises, universities and scientific research institutions are encouraged to carry out industry-university-research cooperation to jointly promote the innovation and development of BIM technology in the field of bridge engineering.

(5) Optimizing information management

The advanced information management system is adopted to ensure that the data generated in the design, construction, operation and maintenance stages of the bridge project can be stored, processed and shared efficiently and safely.

Through the implementation of the above solutions, it is expected to solve the challenges and difficulties faced by BIM technology in bridge engineering to a certain extent, and promote the technological progress and industrial development of BIM technology in the field of bridge engineering.

5. Conclusion

This paper mainly studies the application of BIM technology in the field of bridge engineering, and analyzes its core advantages and disadvantages. The following conclusions are obtained.

(1) BIM technology is mainly composed of CAD design module, construction animation simulation module, terrain processing module and building structure modeling module. The core advantages of BIM technology include visualization, model information management, quantity calculation and cost control, design optimization, collaboration, and high efficiency. BIM technology has played an important role in reducing the amount of engineering calculation, reducing cost waste, improving environmental adaptability, improving design efficiency and accuracy, and providing support for project management and decision-making.

(2) The current challenges of BIM technology include insufficient breadth and depth of technical application, lack of unified standards and specifications, difficulty in modeling, and insufficient technical training and education. The suggestions given in this regard are to strengthen technology research and development, formulate unified standards and norms, expand personnel training, enhance technological innovation, and optimize information management.

(3) The development prospect of BIM technology in the field of bridge engineering is broad, and it plays an important role in improving the quality of bridge design, optimizing the construction process, promoting the digitalization and intelligence of bridge engineering, and improving the efficiency of operation and maintenance management. In the future, with the progress of science and technology, BIM technology will continue to be updated and iterated to bring new vitality and vitality to the entire field and promote the sustainable development of the bridge engineering field.

References

[1] D. Yang, Research on the application of BIM technology in traffic engineering construction, Auto Weekly 08 (2024) 133-135.

[2] G. Huang, Research on bridge design supported by BIM technology, Transportation Science and Technology and Management 5.15 (2024) 25-27.

[3] L. Zhang. Application of BIM technology in bridge construction, High-tech and Industrialization 30.07 (2024) 66-67.

[4] J. Wu, F. Yang, Application research of BIM technology in bridge engineering design stage, Engineering Construction and Design 13 (2024) 173-175.

[5] Y. Mu, Application exploration of multi-discipline collaborative BIM model design of water supply pumping station based on Guanlid and Revit software, Guangdong Water Resources and Hydropower 07 (2024) 104-109.

[6] Y. Li, Y. Chen, BIM based steel structure bridge information operation and maintenance management Technology and Innovation 14 (2024) 149-151.

[7] H. Yin, Y. Dong, Analysis on the application advantages of BIM technology in architectural engineering design, Real Estate World 12 (2024) 131-133.

[8] C. Qi, Research on BIM technology in the design and construction stage of Changqing Yellow River Bridge of Zhengji High-speed Railway, Railway Standard Design 67.06 (2023) 80-86.

[9] W. Wang, J. Wang, H. Song et al., Comprehensive and innovative application of BIM technology in the intelligent construction of the first public rail co-built steel truss girder bridge in Northwest China. China Graphics Society,

The 12th "Longtu Cup" National BIM Competition Award-winning Engineering Application Collection. Shaanxi Huashan Road and Bridge Group Co., Ltd.; Shaanxi Construction Machinery Construction Group Co., Ltd.; Shaanxi Construction Engineering Group Co., Ltd., 2023, pp. 9.

[10] T. Chen, Development status and future prospect of BIM technology in the field of bridges, Stone 10 (2023) 70-72.