Journal of World Architecture, 2025, Volume 9, Issue 2
https://ojs.bbwpublisher.com/index.php/JWA
Online ISSN: 2208-3499
Print ISSN: 2208-3480

Application Strategy of BIM Technology in Bridge Design

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Abstract: BIM technology has become an important tool in road and bridge design. Through the application of BIM technology, the entire bridge process can be modeled to form a virtual bridge form. Through the simulation of bridge construction materials, construction techniques, and construction processes, a comprehensive analysis can be conducted to achieve visualization of the design and improve the efficiency of bridge design. This article mainly analyzes the advantages of BIM technology in bridge design, explores the application forms in bridge design, and proposes strategies to optimize bridge design, providing a certain reference for the improvement and optimization of bridge design work.

Keywords: Bridge design; BIM technology; Advantages

Online publication: April 28, 2025

1. Introduction

In the process of bridge design, various factors such as construction procedures, construction sites, and construction materials need to be fully considered. Therefore, traditional bridge design is difficult, has a long design cycle, and is prone to changes in the later stages of design. The application of BIM technology in bridge design allows for the direct input of construction requirements and measurement data into the system. The system can automatically analyze the design data to form a bridge design model, making the bridge design data more accurate [1]. Furthermore, through the model, potential construction issues can be visually identified and addressed during the design phase, avoiding rework later on, which can lead to wasted construction materials and increased costs. BIM technology has numerous advantages in bridge design, making it the primary tool system for bridge design. However, the current application and development are not yet perfect, and further optimization is possible in subsequent applications.

2. Advantages of BIM technology in bridge design

2.1. Formation of visual structure diagrams

The application of BIM technology in bridge design allows for the creation of three-dimensional, visual design structure diagrams through data input. Designers can preview the design drawings, view the feasibility of the design drawings from different angles of the bridge structure, which is conducive to discovering design problems in a timely manner and optimizing the design results [2]. Additionally, the visual design drawings formed by BIM technology can simulate real-world scenarios, including the application of advanced materials and various pipeline collision tests. This allows for the resolution of design deficiencies from the early stages of design, effectively controlling design costs.

2.2. Achieving intensive construction management

BIM technology expresses advanced design concepts and can accurately analyze models. If design issues are discovered during the design phase, these two functions can be utilized to form clearer and more intuitive inspections, provide corresponding feedback, and demonstrate the application of the design scheme [3]. BIM technology can use simulation systems to present various components in the design. Using auxiliary custom parameters to solve various problems in bridge design improves the quality of bridge design, achieves intensive management of bridge design, provides effective guidance for subsequent design and construction work, ensures construction efficiency, and prevents rework issues later on.

2.3. Improving design efficiency

Bridge construction is susceptible to various forces. To ensure construction quality, the accuracy of design calculations must be guaranteed. However, traditional bridge design primarily relies on manual design methods without utilizing digital technology, which can easily lead to various errors in the design [4]. The application of BIM technology is beneficial for improving the accuracy of bridge design. It can use simulation technology to analyze potential problems that may exist in the design, reducing design errors. Additionally, all design modifications in traditional design require manual adjustments, which can be time-consuming and difficult. BIM technology can revise the design scheme by adjusting parameters, shortening the design cycle and improving design efficiency.

3. Application forms of BIM technology in bridge design

3.1. Assisting in feasibility analysis

In bridge design, it is necessary to fully consider various factors such as the climate and geology of the construction site, which involves a relatively complex analytical process. The application of BIM technology can create a visual design form, coordinate and simulate bridge engineering projects, digitize complex data, and provide designers with more standardized reference solutions [5]. Simultaneously, BIM technology can also be applied to the surveying and mapping process, enabling advance simulation analysis to avoid significant changes during construction and providing necessary supplements for subsequent design work. BIM technology can further utilize 4D technical means to simulate the construction process during the design phase, locate construction equipment, retrieve relevant control routes and information, and break traditional management modes. Therefore, in the construction of BIM models, it is essential to ensure the accuracy and authenticity of the data.

3.2. Batch output of design outcome documents

Design drawings are the primary basis for subsequent construction in bridge design. By adopting BIM technology, detailed inspections of bridge design elements can be conducted using software systems, design drawings can be verified, defects and insufficiencies can be identified in a timely manner, and rectifications can be made to address these issues, enabling drawing verification and review. During the operation of BIM technology, directly inputting component parameters can facilitate the updating of design drawings [6]. Additionally, in the initial design of drawings, data associations can be established between components, allowing for information changes to occur automatically when one data point is modified. This enables batch modifications in drawing design, improves drawing design efficiency, and ensures the quality of drawing design.

3.3. Engineering quantity statistics application

In bridge engineering design, engineering quantity statistics is a crucial aspect. Traditional engineering quantity statistics primarily rely on two-dimensional plan design drawings, where information between various components is independent and requires sequential analysis. If design requirements change, the engineering quantities of each component need to be updated promptly, and all related data must be modified, increasing the workload in bridge design. The application of BIM technology in bridge design effectively addresses these issues. BIM technology allows for the creation of virtual bridge models through parameter input and enables precise statistics on cost information and materials related to various components based on the model. By utilizing this data, custom formulas for calculating various engineering quantities can be constructed, enabling automatic statistics and calculations even when data changes.

Additionally, Revit software can be employed to generate detailed information commands for various parameters during drawing design, which are used for engineering quantity statistics. Furthermore, in bridge construction, large amounts of steel bars, concrete, and other construction materials are used, with variations in material specifications and shapes depending on the location. Traditional manual calculations require multiple statistics based on material classification [7]. Moreover, it is necessary to add various information such as material type and specifications to the statistical and calculation details, increasing the computational workload of the project. With BIM technology, data input directly follows pre-designed commands to complete various engineering calculations.

3.4. Construction process simulation application

The primary purpose of bridge design is to provide a reference for subsequent construction, ensuring the safety and efficiency of later construction work. Therefore, bridge engineering design must be reasonable to avoid design changes and rework due to issues discovered during later construction, which can affect construction progress and increase costs. Traditional bridge design primarily relies on drawings and written proposals. This two-dimensional design approach is less effective for presenting complex processes, making it difficult to fully exhibit all design details. The lack of intuitive design drawings can hinder designers' comprehensive consideration of the design scheme [8]. The application of BIM technology enables the creation of three-dimensional visual models during the design phase, allowing for the simulation of the entire bridge construction process.

Especially for concealed construction content or structurally complex locations, software simulation ensures the rationality of construction procedures and achieves better construction results. In simulation applications, BIM technology can disassemble the bridge model into multiple small units through coding, ensuring that each unit's procedures meet construction principles and generate procedure codes. Subsequent construction plans strictly follow the division of procedures, and the allocated procedure content is imported into the workbench to simulate the construction process. This allows for adjustments and optimizations of the construction scheme based on the arrangement of construction procedures. Additionally, BIM simulation technology can simulate the craftsmanship in bridge construction, ensuring the rationality of construction procedures. For example, in the construction process of prestressed tendon formwork, BIM technology models can be utilized during the design phase to establish standard controls for construction workload and quality control points, improving operational efficiency.

3.5. Bridge design conflict testing

BIM technology is widely used in bridge collision conflict experiments. Through BIM collision conflict testing, the rationality of the position of all components in bridge design can be ensured, avoiding problems of component crossover and collision in subsequent construction and guaranteeing the safety of the bridge construction structure. Most collision conflict detections require breaking the two-dimensional spatial layout mode and coordinating from three-dimensional space to ensure that all constructions do not form obstacles in the three-dimensional distribution [9]. Firstly, in the preparation stage of design, the application of BIM technology can integrate and consolidate all information, incorporating various design elements into one environment. Simultaneously, the accuracy of various parameters is tested to ensure they meet the granularity requirements of the detection.

Secondly, it can be used for model building. After the BIM model is constructed, collision conflict detection is directly performed on the virtual platform, automatically scanning and finely distinguishing various potential conflict areas in the design, especially the large number of pipelines involved in the bridge, which can be displayed in a timely manner once there is a conflict collision. Finally, the collision detection software can visualize the locations of conflicts and generate reports to reflect the problems between components and make timely adjustments. In BIM technology-assisted bridge design detection, potential problems in construction can be investigated during the design phase, reducing the probability of workload changes later and ensuring the safety of bridge construction.

4. Application strategies of BIM technology in bridge design

4.1. Improving BIM design models

The application of BIM technology in bridge design allows for the integration of main structural information of the bridge. However, bridge design is difficult to achieve in one step, and there are many areas that require optimization later. Overall, the application of BIM technology in bridge design demonstrates strong design interactivity. Designers can use BIM technology to more intuitively view the three-dimensional drawings of the bridge and adjust the drawings according to design needs. Simultaneously, adjustments to the data in the model can be made to update the overall structural design. In the application of technology, the uniformity and standardization of all data must be ensured. BIM technology can standardize various data and improve the accuracy of the model. Especially with the improvement of BIM technology's computing power, the control over the accuracy calculation of the design model will be stronger, and the design of bridge components will be more refined. This requires that the model constructed by BIM technology must handle the details of each location, breaking the single structural model. Attempts can be made to combine it with models such as pipelines and electromechanical components in the bridge structure to form a more complete design scheme and make the bridge design model collaborative.

4.2. Optimizing bridge design schemes

Before starting bridge design, it is necessary to determine the bridge structure and construction scheme, which serve as references for the design drawings. The design also needs to be preset in advance based on the design scheme. However, due to factors such as early surveys and design ideas, there will inevitably be some defects, making it impossible to achieve a one-time design. Additionally, traditional CAD software uses a two-dimensional image design method, which is not conducive to reflecting bridge features. If errors occur in the referenced design during bridge construction, there will inevitably be problems of rework or stoppage in later construction, which will have a huge impact on bridge construction [10]. The application of BIM technology in bridge design projects is conducive to optimizing and improving bridge design projects and promoting the smooth progress of construction projects. BIM technology's prediction and simulation functions can also be utilized to input corresponding data into the bridge model, form data analysis, and construct a three-dimensional model. This enables comprehensive inspection of the design project, avoiding leftover issues, and preventing situations such as non-compliance or lagging progress in later construction.

4.3. Enhancing designer capabilities

BIM technology is still emerging for bridge design work. Although it has many advantages in design applications, there are still a large number of potential functions that have not been effectively developed. To ensure the effectiveness of BIM technology in bridge design, it is necessary to strengthen technical training for designers. All designers need to participate in theoretical and operational training on BIM technology concepts, principles, and more, to ensure that everyone is proficient in BIM technology and understands the application methods of the system. Advanced training should be regularly conducted so that designers can receive higher-level training after having a certain foundation in BIM design. For example, collaborative design, data analysis, and other methods can be adopted to enhance designers' skills and improve their BIM technology application abilities. To enhance designers' practical abilities, it is necessary to strengthen practical exercises in BIM technology, simulate bridge design environments, and improve designers' problem-solving abilities. Additionally, a BIM technology exchange group can be established within the enterprise, where designers can exchange design experiences, raise design questions, and discuss them together, creating a good learning atmosphere. Furthermore, regular BIM technology exchange meetings can be held to showcase BIM design achievements and share design insights. Technical evaluation and incentive levels can also be set up to stimulate employees' enthusiasm for BIM technology.

5. Conclusion

In summary, the application of BIM technology in the design phase of bridge engineering can create a visual design model for the design project. By inputting parameters, a three-dimensional design scheme can be completed, which is beneficial for designers to discover problems in bridge design and make timely rectifications, reducing later engineering changes. At the same time, it can also combine design needs to obtain new design models through parameter changes, shortening design time and ensuring design efficiency. It can also be applied to work such as engineering quantity calculation and design collision contradiction experiments, minimizing mistakes made in the initial design stage and providing more accurate references for subsequent bridge construction. Therefore, in the application of BIM technology, it is necessary to strengthen the optimization of design models, improve design schemes, and enhance designer training to promote the effective use of BIM technology functions.

Disclosure statement

The author declares no conflict of interest.

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