Journal of World Architecture, 2023, Volume 7, Issue 6
https://ojs.bbwpublisher.com/index.php/JWA
Online ISSN: 2208-3499
Print ISSN: 2208-3480

Design Strategy of Municipal Roads and Bridges Using BIM Technology

Meng Wan*

China Merchants Chongqing Communications Technology Research & Design Institute Co., LTD., Chongqing 400067, China

***Corresponding author:** Meng Wan, m18008376826@163.com

Abstract: Under the rapid development of socio-economy and urbanization, the state's attention toward urban infrastructure continues to increase. The construction of municipal road and bridge projects is related to people's daily travel and transport safety, and it also plays an important role in promoting urban economic development. Therefore, modern technology should be fully utilized in the design of municipal roads and bridges to strengthen construction cost control and increase their social and economic benefits. In this paper, the characteristics and application status of BIM technology in municipal road and bridge design are analyzed, and corresponding road and bridge design strategies are explored to promote the healthy development of municipal road and bridge projects.

Keywords: BIM technology; Municipal road and bridge; Design

Online publication: December 26, 2023

1. Introduction

In view of urbanization, the government has increased its investment in infrastructure construction, thus the number and scale of urban infrastructure construction have been expanding. Urban municipal roads are one of the important urban infrastructures, especially under the increasing number of cars and the rapid development of the logistics industry, and new requirements have been put forward for the construction of municipal roads and bridges. In the design of municipal roads and bridges, it is necessary to strengthen the analysis of engineering characteristics to ensure the accuracy of the design. This can be achieved by optimizing the designs of municipal roads through modern technology.

2. Characteristics of BIM technology in municipal road and bridge design

2.1. Design visualization

The most prominent feature of BIM technology is that it can better visualize design drawings and provide a three-dimensional image of the design. With the visualization model, the problems in the road and bridge design can be identified, and the synergy between the design and other various construction contents can be

understood. Moreover, the software offers intelligent analysis, which can detect unreasonable designs and provide countermeasures, which in turn help optimize the design scheme.

Accurate and comprehensive three-dimensional visualization models cannot be achieved through traditional plane drawings, particularly for complex structural designs. This limitation can lead to various engineering problems, ultimately impacting the project's quality.

2.2. Design optimization

BIM technology enables the creation of three-dimensional models for municipal road and bridge design. This allows for simulation, issue identification, and improvement during project development. Unlike traditional plane analysis, BIM helps detect problems earlier, not just during the construction stage. Constructing a BIM model facilitates timely design improvements, allows for reasonable adjustments to drawings, and helps prevent issues that could impact construction progress. Furthermore, it strengthens design optimization, improves the project's cost-effectiveness, and shortens the construction period.

2.3. The virtuality of the design model

Complex processes and construction challenges in road and bridge projects are often challenging to accurately depict in two-dimensional drawings. BIM technology, utilizing virtual modeling and parameter uploading, addresses this issue by creating a virtual design mode. This facilitates design modifications, and timely adjustments to the design scheme, and helps avoid delays in later construction.

2.4. The synergy of all links

Road and bridge engineering construction involves many aspects, including roadbeds, pavements, bridges, piers, water supply and drainage, etc. BIM technology enhances the design display, enabling more professional representation and effective information integration. This facilitates seamless connectivity and the sharing of diverse construction information among designers. Besides, BIM technology is also customizable. Design units can provide the design parameters to suppliers based on the construction framework contract, enabling the sharing of construction resources. At the same time, BIM technology allows a three-dimensional display of roads and bridges, which helps clarify design ideas, reduce design errors, and ensure the standardization of road construction. Moreover, the application of BIM aids in ensuring that materials used in the project are qualified, conducting accurate cost budget and accounting analysis, and proficiently managing material quantity statistics[1].

2.5. The goal of the project design

The application of BIM technology allows timely discovery of problems and loopholes in the project design. It allows for optimization in terms of project cost, cost control, and construction safety considerations, ensuring that the design aligns with construction requirements. In municipal road engineering, building a three-dimensional model is essential for construction efficiency, taking into account the construction period and reducing the incidence of safety accidents.

3. Application status of BIM technology in municipal road and bridge design

3.1. Limited application

China's extensive land area and complex geographical structure exhibit significant variations in environmental conditions across regions. The construction of municipal roads and bridges in China involves a lengthy process with numerous stages. Additionally, it often results in a cross-regional pattern, covering a wide range

of construction activities. Municipal road and bridge design can be affected by many factors, including hydrogeology, terrain, and topography, as well as traffic, climate, and other factors. Among them, the geographical environment is the most complex factor. Therefore, it is necessary to consider both the construction quality and construction difficulty of the municipal road, strengthen the optimization of the construction design scheme, ensure effective cost control, and increase investments in these kinds of projects. The current application of BIM technology in municipal road design cannot effectively highlight the construction function of certain complex sections or procedures due to the immaturity of construction technology [2].

3.2. Limitations of professional software

BIM technology requires advanced computer technology and software. While the application involves inputting parameters after modeling to generate design drawings, it is essential to ensure the software's feasibility and efficiency. Currently, most construction software used in China is adapted from existing foreign computer software, lacking integration with local engineering characteristics and optimization. This results in poor software adaptability. Additionally, differences between architectural engineering design and municipal road design impact the effectiveness of BIM technology applications.

3.3. Limited technical skills

Although BIM technology offers a paramount of advantages in municipal road and bridge design, its effective utilization requires proficiency from designers. Presently, municipal road engineering designers possess strong professional skills and theoretical knowledge of road and bridge design. However, challenges arise in integrating road and bridge design with computer technology. Difficulty in mastering computer technology leads to limitations in the application of computer software, restricting the innovative use of BIM technology.

4. Application strategy of BIM technology in municipal road and bridge design

4.1. Application at the project initiation stage

BIM technology can be applied at all stages of municipal road and bridge design. Firstly, in the project approval stage, BIM technology can be used to verify and analyze the feasibility of the road and bridge design scheme. This helps prevent deviations between the design and the actual construction, which will affect the construction progress. Moreover, the application of BIM technology across various fields contributes to the enhancement of various technical systems. This, in turn, elevates the technical proficiency of designers, enabling more effective analysis of design schemes. The optimization of municipal engineering design schemes, guided by BIM, serves as a valuable direction for municipal engineering construction. In addition, with BIM technology, designers can form a variety of design solutions in the project stage. Through the analysis of potential factors in these solutions, designers gain insights into subjective and objective conditions limiting program implementation. The construction of a three-dimensional model facilitates the optimization of the design scheme.

4.2. Application in site planning

Site planning is one of the crucial aspects in the design of municipal roads and bridges, which will affect the quality of engineering construction. In traditional municipal road construction, site planning is done by manual measurements, making the data collected less accurate, thus affecting the quality of road construction [3]. The application of BIM technology enhances the precision of construction site delineation, ensuring accurate measurements and contributing to the quality improvement of municipal road projects. BIM transforms abstract two-dimensional graphics into visual and three-dimensional representations during the division of municipal

engineering sites. This visual clarity aids designers in intuitively understanding site divisions, which is crucial for site layout and engineering design schemes. This helps avoid design modifications during construction, effectively controlling construction costs and ensuring the economic benefits of enterprises.

4.3. Application in centerline drawing

The drawing and design of the centerline directly affect the overall design effect of the road and bridge project. Centerline design is easily affected by many factors, making it difficult to guarantee the accuracy of the centerline. To ensure the accuracy of centerline design and drawing, designers should prioritize attention to limiting factors in construction. The centerline's position should be determined based on the design regulations. In centerline drawing using BIM technology, the initial stage involves implanting and effectively controlling the centerline. Subsequently, after determining the specific location, the centerline is designed in conjunction with 3D drawings. During the centerline conversion, a multi-segment transformation is carried out based on the 3D map, strictly adhering to relevant regulations. Finally, it is crucial to enhance route innovation for municipal roads and bridges. By utilizing the route menu, designers can innovate new routes during construction. After executing this function, they can select the corresponding input taskbar, create the line name, add line labels, and thereby complete the line design.

4.4. Application in engineering quantity calculation

BIM technology encompasses rich data information and exhibits intelligent and digital characteristics. Its application involves utilizing various information to automatically identify components in the model. By combining this with the physical and geometric embedded information of the model, it facilitates automated quantity statistics [4]. For instance, in road engineering's bridge design calculation, components can be classified, and automatic statistics can be applied for walls and their detailed information. By replacing drawings with models, the number, names, and specifications of components in the building can be generated. When there are changes in the design, the corresponding parameters will be adjusted automatically. This automated quantity calculation is more scientific and faster, freeing designers from complex calculations while ensuring accuracy [5].

4.5. Box beam design and application

Currently, most bridges adopt the design of steel box girder, which can ensure the safety of the bridge box and the stable operation of the bridge. The structure of bridge steel box girder is relatively complex, most of them are prefabricated in the factory before being transported to the construction site for installation. Traditional two-dimensional drawings struggle to depict the project's details comprehensively, resulting in less refined and clear representations. To address this, various design solutions are needed for optimization and adjustment, forming a more detailed design mode. This ensures both the progress and quality of the later construction engineering [6]. The application of BIM technology in the construction of roads and bridges can effectively circumvent these problems. By creating a three-dimensional model through BIM, the design can be analyzed from different perspectives. Besides, and two-dimensional profiles from different perspectives can also be obtained, ensuring the accuracy of the production and processing. This enhances the efficiency and quality of steel box girder production.

4.6. Application in underground pipelines

Pipeline design plays a crucial role in municipal engineering road and bridge design, directly impacting the operational efficiency of each system. In urban road construction, the arrangement and structure of underground pipelines can be complex, particularly in older city areas, often leading to unexpected challenges

during construction. These challenges necessitate adjustments in the design process, resulting in engineering modifications to address the intricacies of underground infrastructure in urban settings [7]. The integrated design of pipelines plays a crucial role in balancing the horizontal and vertical relationships of different professional engineering aspects. Traditional municipal pipeline distribution primarily focuses on analyzing the plane distribution, comprehensive cross-section, and intersection node positions of the pipeline. However, this approach provides limited information, making it challenging to comprehensively analyze the overall structure of the pipeline and leading to potential conflicts between pipelines. To ensure the effective design of roads and bridges, it is essential to comprehensively collect project information, understand the orientation of new and existing pipelines, and gather parameters for each pipe diameter. The use of BIM technology facilitates the creation of a dynamic pipeline distribution model, offering a more scientific representation of the relationships between pipelines [8]. Virtual technology within BIM is employed to conduct pipeline collision tests, generating corresponding reports that serve as a basis for construction work.

4.7. Application in landscape design

Road and bridge construction is followed by the design of the surrounding landscape. To avoid destroying the ecological environment in the landscape design, the concept of environmental protection and green development should be integrated into the project construction. Through the optimization of the landscape design, the contradiction between the construction project and the ecological environment can be solved. BIM technology can be used to simulate the landscape design scheme of road and bridge construction. This includes constructing an engineering landscape model, facilitating a better understanding of the spatial distribution of the landscape [9]. BIM allows for a clearer and more intuitive display of spatial distribution, and potential ecological damage resulting from construction can be reduced. Besides, BIM software dynamically presents the surrounding landscape in conjunction with climate, geology, and other conditions at the construction location, ensuring the feasibility of the design scheme [10]. Moreover, BIM technology can be applied to showcase the design of streetlights at both ends of the road bridge. It allows for the demonstration of the irradiation range and effect of different lightings, facilitating the creation of the best design scheme.

5. Conclusion

In conclusion, the application of BIM technology in municipal road and bridge design enhances the scientific nature of the design process. By creating a three-dimensional model through visualization and virtualization, the project becomes more observable, allowing for an intuitive examination of each link and detail. This aids in optimizing and improving any unreasonable aspects, reducing the need for subsequent modifications. However, the current application of BIM technology has certain limitations, requiring further optimization. Tailoring BIM technology to specific engineering design content can lead to better design results, offering valuable insights for municipal road and bridge construction and ensuring safer daily travel for people.

Disclosure statement

The author declares no conflict of interest.

References

[1] Wang HY, 2021, BIM Technology Application in the municipal road and bridge Design Optimization. Journal of

Packaging World, 2021(5): 70.

[2] Li XH, 2021, BIM Technology Under the Condition of Municipal Road and Bridge Design Study. Journal of Packaging World, 2021(5): 66.

[3] Liu Z, 2020, Municipal Road and Bridge Design Based on BIM Technology Explore. Science And Technology Innovation and Application, 2020(23): 102–103.

[4] Chen Q, 2020, Research on Design of Municipal Road and Bridge Based on BIM Technology. Engineering Construction and Design, 2020(2): 253–254.

[5] Rao YP, 2020, Municipal Road and Bridge Design Based on BIM Technology Explore. Journal of Sichuan Cement, 2020(3): 38.

[6] Li Y, 2021, The Application of BIM Technology in Road and Bridge Design Optimization Analysis. Journal of Architecture and Decoration, 2021(5): 81.

[7] Zhang L, 2021, BIM Technology in Road and Bridge Design Optimization Applications. Journal of Construction Engineering and Design, 2021(24): 72.

[8] Zhang JL, 2020, Application Research of Road and Bridge Design Based on BIM Technology. Real Estate Guide, 2020(32): 88.

[9] Chen J, Research on Municipal Road and Bridge Design Based on BIM Technology. The Construction, 2021(18): 140–141.

[10] Li T, Qian Y, 2022, Optimization and Application of BIM in Road and Bridge Design. Brick World, 2022(11): 172–174.