Application of BIM in Highway Engineering

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Abstract. The layout of new infrastructure construction around digital transformation is an important proposal in the national "14th Five-Year Plan". Building Information Modeling (BIM) has multi-dimensional model information integration technology, responds to the national call, and meets the needs of innovative development and digital transformation and upgrading of highway construction. In recent years, BIM has developed rapidly in the engineering field. In this context, this paper studies and summarizes the technical standards and specifications of BIM technology in the highway field, design software, and the application of BIM technology in engineering puts forward the problems existing in the current promotion of BIM technology, and looks forward to the future of BIM technology application in highway engineering.

Keywords: BIM technology, Highway engineering, applied technology.

1. Introduction

In recent years, BIM technology has been popularized rapidly in the field of highway engineering. BIM technology is a new technology integrating modern information technology and computer technology. With digital storage, 3D model-oriented and object-oriented, it has realized the whole process informatization of engineering design, construction, maintenance, and operation management, and has gradually become the focus of research and discussion among scholars. Among them, early research focused on highway design. With the deepening of research and the promotion of BIM technology, BIM technology gradually covers various fields of highway engineering. From the existing literature, BIM technology has initially established standards and specifications, has a relatively rich design software, and is widely used in engineering design, engineering cost, construction quality control, and engineering management. Based on the application status of BIM technology, this paper analyzes the application of BIM technology in engineering and puts forward the existing problems, aiming to accumulate experience for the application and promotion of BIM technology in this field.

Overview of BIM technology BIM is a series of revolutionary software related to engineering construction for the second time after CAD technology, and it is the product of the impact of the information age on engineering construction. As an application system widely used in the construction industry, it relies on powerful data processing technology and 3D model building technology to build a 3D information database, which can accurately simulate the actual situation of the construction site. First, in the construction scheme design stage, compared with the traditional two-dimensional drawings, the intuitive three-dimensional information model strengthens the communication between different personnel, reduces ambiguity, and enables all participants to have a more unified understanding of the scheme. Through the collection of information, we can achieve scientific and accurate control of the project, accurately simulate the complex situation of the construction site, avoid possible accidents and potential safety hazards, reduce risks, and effectively improve the efficiency of project construction. Second, for the construction personnel, the three-dimensional information model can enhance the information transmission, enhance the construction personnel's understanding of the scheme, improve the accuracy of the information transmission, promote the accurate implementation of the design scheme, and ensure the accurate control of the whole process of the project construction through the analysis of the information. Thirdly, BIM technology reduces the risk of collision of embedded parts in foundation and subgrade construction. 3D information directly and accurately reflects the layout of each component, which is convenient

for designers to optimize the scheme, reduces communication costs, and reduces the risk of mutual extrusion of embedded parts and collision of pipeline in the project.

2. Application Status of BIM Technology in Highway

2.1. BIM technical standards and specifications

Highway construction is the focus of infrastructure projects and the cornerstone of promoting local economic construction and social development. In the 14th Five-Year Plan, the government and enterprises around the country made important proposals around digital transformation and new infrastructure construction. A series of BIM-related standards were issued, such as the Unified Standard for Application of Highway Engineering Information Models, the Standard for Application of Highway Engineering Design Information Models, and the Standard for Application of Highway Engineering Construction Information Models, which stipulated the model architecture, classification coding, data storage, and construction delivery requirements, and initially established the BIM technical standard system, thus solving the model architecture of highway facilities, Basic problems such as model coding and data format. It standardizes the technical requirements for the application of BIM technology in the whole life cycle of highway engineering construction and promotes the standardization and systematization of BIM technology applications in China. Under this basic framework and system, local highway societies and enterprises have also participated in the field of highway engineering, promoting the application and development of BIM technology in various fields of the highway industry.

2.2. 3D BIM design software

In highway engineering, currently widely used software includes Solidworks, Bentley, Autodesk, and other foreign software, as well as domestic secondary development or self-developed software. The Autodesk software platform provides a complete set of software solutions focusing on civil 3D, Revit, and Naviworks in highway BIM design. Relying on the technology and market accumulated by this software platform in the era of two-dimensional drawing and modeling, it has a high popularity and customer coverage and is widely used by colleges and universities. The Openroads Concept, Openroads Designer, and Infrastructure in Bently software solutions are all developed on its Microstation 3D graphics platform. Adhering to the concept of one platform, one data format, and one BIM model, BIM provides BIM solutions for large databases and large volume models for multi discipline and complex infrastructure construction of highway construction. Solidworks software launched the "CATIA civil engineering software design package" serving the transportation industry. Through cooperation with domestic design enterprises, it has realized digital terrain simulation, civil engineering 3D modeling, data interface, and other functions. At present, the auxiliary modeling software based on the secondary development of foreign general platforms is widely used in China. For example, the CNCCBM series software of CCCC First Highway Engineering Co., Ltd. (based on the Bentley Openroads platform) realizes the three-dimensional BIM design of roads, bridges, and tunnels, and provides a systematic scheme for BIM design, plotting, and digital delivery[1].

3. Application of BIM Technology in Highway Engineering

3.1. Design review

The design scheme of the highway project is an important part of the whole project construction link, which is the basis to ensure the smooth progress of each construction link and ensure the project quality. In the past, the traditional design relied on the two-dimensional plane model, and different staff had deviations in their understanding of the drawings, which easily led to ambiguity. There were many disputes when carrying out the work, which also affected the rationality and accuracy of the design scheme. The introduction of BIM technology, relying on its powerful 3D modeling and digital

information visualization capabilities, As shown in Figure 3-1, enables the design scheme to be presented in the form of a 3D information model, so that different personnel can intuitively understand the details of the scheme, reducing the understanding deviation of the construction design scheme, and reducing the difficulty of communication between designers. (Figure 1)In the simulation construction stage, the construction process can be continuously optimized according to the problems existing in the construction design scheme, so that the simulation scenario can gradually adapt to the actual project construction scenario, achieve the best simulation effect, and avoid the risks in the actual construction[2]. In the review stage, by modifying the parameters of the design model, the modified 3D model effect can be presented intuitively, reducing the risk of hidden problems. The efficiency and accuracy of design review are improved, and the time cost of design review personnel and the workload of other relevant personnel are reduced. The application of BIM technology in the design review process ensures that the design scheme is scientific, accurate, and meets the predetermined design requirements while improving the work efficiency of the participants, and greatly shortening the design cycle. It has laid a solid foundation and provided strong support for the smooth progress of the construction project.



Fig. 1 Three-dimensional model of two-way single-lane passing---bridge for Shandong Jiaotong College

3.2. Engineering cost control

In the construction preparation stage, due to the insufficient optimization of the design scheme, the construction scheme is inconsistent with the actual situation during implementation, leading to the cost being out of control. The introduction of BIM technology, through its collision detection and 3D simulation animation display functions, reduces the gap between the scheme and the actual construction site situation, reduces the possibility of rework, and controls the increase of project cost. In the construction stage, due to the difficulty in coordinating material resources, design changes, high difficulty in information sharing, difficulty in managing construction progress payments and other issues, cost control is often out of control. Through the application of BIM technology, construction personnel can use BIM technology to take model quantities in material distribution, improve the utilization rate of site and transportation machinery, and reduce the difficulty of material resource planning. The three-dimensional information model provided by BIM technology can better control design changes, better calculate the cost and effect after changes by changing one data and the effect of multiple changes, and clarify whether changes are needed, so that the cost of changes can be controlled, and can intuitively reflect the information of payment changes, improving the payment situation[3].In terms of quantity calculation, through its huge database function, the total quantity can be accurately calculated and a detailed list is provided.

3.3. Construction quality control

Project quality is the foundation of the construction unit and the top priority of project management. The actual situation of the construction site is relatively complex and vulnerable to various external factors. Dynamic monitoring of various data during construction is required. The three-dimensional information model and huge database of BIM technology provide real-time data, control the whole process of data collection, analysis, and processing, ensure the accuracy of parameters and

components, facilitate the comprehensive analysis of data, achieve fine management, make all links of construction closely linked, improve the level of on-site management, and help continuously optimize the construction process, Reduce the influence of external adverse factors.

3.4. Management of construction facilities, materials and manpower

Any problem in any link of the construction will directly affect the construction progress and scheme formulation of the whole project, so it is very important to carry out systematic management of on-site manpower, equipment and materials. As shown in the figure 3-2,The information visualization and real-time of BIM technology can effectively supervise the material quality, ensure the efficient and safe operation of equipment, further ensure the life safety of staff, improve the management level of construction site, and guarantee the smooth progress of the project[4].(Figure 2)

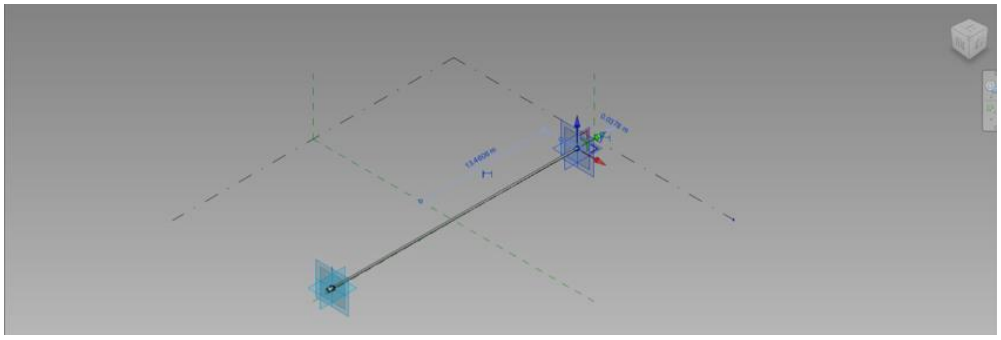


Fig. 2 Acquisition of component data through 3D modeling

4. Current problems

4.1. Standards and norms

The three published highway BIM standards and specifications have initially established China's BIM industry standard system. There are principled and overall specification requirements for model creation and design, but there are no clear requirements for specific delivery data structures, leading to inconsistent data levels, increasing the operational difficulty of designers in the design process, and reducing the design efficiency. Various highway societies, provinces and cities have proposed their own standards, but the specifications of different levels or cities are quite different, or even conflict with each other. Practitioners often need to change plans and modify modeling according to different focuses of different specifications, which results in a lot of time and energy consumption, and also makes it difficult to guide the implementation of projects with BIM technology. In addition, there are many enterprise level and project level BIM platforms at present, but the data storage format is not unified, and the interfaces are not open to each other, which makes it difficult to transfer data between platforms and restrict multi discipline collaboration.

4.2. Independent software development

At present, various BIM software used in China has its own advantages in different fields, but these software are basically foreign software, and the foreign software directly imported and purchased cannot meet the requirements of domestic projects well. At present, the domestic software design and R&D work mainly focuses on the secondary development of APIs provided by these platforms, and is basically based on project requirements, with limited functions, which does not meet the requirements of full professional, full stage and standardized highway design and application. It is also difficult to ensure the safety and controllability of the research and development achievements using the basic platform of foreign manufacturers. At present, the domestic software platform started late, and paid more attention to the development of the construction field in the early stage, but less attention was paid to the highway field. At present, the domestic software platform cannot be directly used for highway design, and it will take a lot of time for secondary development.

4.3. Project Applications

The advantage of BIM technology lies in its huge database and professional 3D modeling function. The greatest value lies in the forward design of 3D models and attribute information transmission function throughout the project life cycle. However, at present, many BIM designs are only designed to respond to policy requirements, improve the competitiveness in bidding, meet the needs of owners, and even reproduce two-dimensional models to generate three-dimensional models. They do not improve the level of design, simulation, and management through the advantages of BIM technology, and also run counter to the original intention of introducing BIM technology into the highway industry. In addition, engineering management relies on personnel in all links to change the data model in a timely manner, but the personal technical literacy of some practitioners cannot keep up with the speed of BIM technology promotion, which also leads to the limitation of BIM technology promotion[5]. At present, the application of BIM technology mainly focuses on the single point visualization application in the early design stage, such as live modeling, pipeline collision, scheme comparison, etc., as well as the collaborative, simulative and visual application of 3D information model in engineering management. Failed to form a set of BIM solutions that can be applied to all stages of highway engineering. It also affects digital deliverables.

5. Conclusion

BIM technology is the basic tool to realize the informatization and digital transformation of traditional construction mode. Under the background of a powerful transportation country, BIM technology will play an increasingly important role in the process of highway engineering digital construction. At present, although the application and promotion of BIM technology are facing many problems, it is difficult to start everything, but as long as we do a good job in technical reserves, strengthen the quality training of practitioners, and actively respond to national policies, we believe that BIM technology will blossom and bear fruit in various fields of highway engineering, and lay a solid foundation for the digital transformation of highway engineering.

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