

Advantages and Development Prospects of Building Information Modelling (BIM) Technology Application in Highway Engineering

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Abstract: Based on the advantages of the application of Building Information Modelling (BIM) technology in highway engineering, this paper analyzes the difficulties of its in-depth application, grasps the pain points of the application of BIM technology in practice, and approaches from the integration of BIM design-construction. This paper also puts forward the integration of cross-stage information based on the BIM + Geographic Information System (GIS) construction information management system to realize the BIM whole life cycle management, and provides directional support for the continuous and efficient application of BIM technology in engineering practice.

Keywords: BIM technology; Highway engineering; Application advantages; Development prospects

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1. Introduction

With the increasing scale of highway project management system, the traditional information management platform inevitably generates problems such as performance degradation, expandability deterioration, and operation and maintenance difficulties when coping with such a complex system, thus limiting the adaptability and practicability of the system platform^[1]. Although the state has put forward a clear deployment and policy orientation for the application of Building Information Modelling (BIM) technology, compared with foreign developed countries, there is still a certain gap in the application of BIM in China. On the one hand, relevant domestic departments should further strengthen the policy guidance and support to promote the popularization and application of BIM technology. On the other hand, construction industry enterprises should actively innovate, perform research and development, increase the promotion of BIM technology, improve the application level, and improve the technology chain^[2]. Highway engineering construction process management based on BIM technology can improve the quality of the project, reduce the construction cost, and optimize the construction progress, which is an opportunity for change in the field of highway engineering management^[3]. There is still a big gap between digital transformation and informatization construction in the field of domestic

highway construction, and it is necessary to further strengthen forward-looking technical research and policy guidance^[4].

BIM technology, as a fundamental application, will provide strong technical support for engineering BIM application and intelligent transportation due to its three-dimensional (3D) visualization and data integration capabilities. This paper takes the highway engineering design-construction process as the research object, carries out the application research in the construction phase of highway engineering, and explores its application advantages and development prospects.

2. Advantages of BIM technology application on highway engineering

2.1. Data synergy and interactivity

Synergistic interaction is an important part of the management process of all construction projects, and it is also necessary to form a positive and cooperative relationship between the construction company, designers, and direct participants in the construction project. However, with the development of information technology, the shortcomings of Computer-Aided Design (CAD) technology have been gradually exposed, and the synergistic relationship between the various links and roles in highway construction has not been effectively established. BIM technology, as a new technology, a new space, a new way of thinking, and a new program, encompasses the information model of the whole life cycle of highway construction, and at the same time, it covers all the data of the behavior of project management. The perfect integration of the two has brought about sweeping changes in information technology to the highway construction industry. For example, BIM technology can discover relevant conflict problems in the design stage of construction project in advance, report the conflict of each specialty in the pre-design stage through collision detection, and further optimize the design by discovering the corresponding conflict location through the conflict report. With BIM technology as a tool for information support, project participants using BIM technology can realize data sharing and business exchange in a unified information platform. BIM integrates project-related information in all stages of the project, which can prevent the occurrence of information complexity, loss, and reduced exchange efficiency that are easy to occur in traditional project management.

2.2. Visualization

The different BIM dimensions such as 3D solid model, 4D progress model, 5D cost control, 6D quality management, 7D safety control, and Nth generic dimension (nD) management application comprehensively show the whole picture of the project site, and at the same time, each component is detailed, so that the project management becomes clear and visible. It can also realize the whole process of bidding, tendering, planning, construction, and operation, as well as the visualization of communication, discussion, and decision-making.

For example, after the application of BIM technology in the process of investigation, design, and construction of highway projects, it can significantly improve and enhance the visualization effect of the results, improve the level of design and construction quality, and facilitate the effective connection of all parties involved in the construction project. Moreover, the formation of the BIM data system is conducive to the project owner's operation and management in the later stage, and to the construction of the whole life cycle of transportation construction projects and the building of the system, which saves the national investment and construction funds, shortens the construction period, and guarantees the operation and maintenance of the project^[5-7].

2.3. Facilitating information management

In traditional construction management, various problems in the project will usually be categorized according to

quality, progress, cost, and safety categories. However, BIM technology directly connects the above problems with the names of model component locations, which is not only well done, but also well done in the later work.

2.4. Integration

BIM technology can help highway projects to achieve integrated management of the whole life cycle, from design and construction to operation and maintenance, and provide efficient, accurate, and reliable decision support for highway construction, so as to optimize the management and control of the whole project.

3. Difficulties in the application of BIM technology on highway projects

3.1. BIM system application requires a high degree of technical integration

BIM application needs to be seamlessly connected with the industry's technical knowledge system, the synergy of information and data is particularly important, but it also needs to integrate Geographic Information System (GIS), Internet of Things (IoT), Information and Communications Technology (ICT), big data, cloud computing, and other new technologies. However, many new technologies are still in the development stage and cannot efficiently support the BIM model of high-efficiency, high-precision, real-time application of the data requirements, so the application of BIM technology in the management level needs to be explored. Moreover, the development of highway engineering is lagging due to its larger span, more complex influencing factors, and higher technical requirements, and many application practices have transferred technical difficulties.

3.2. Lack of software development and application standards and specifications

BIM technology in the field of highway construction is in the process of gradual development and promotion, and application of practice, data silos, and data exchange problems gradually emerged. The domestic application and promotion of standards such as Information for Construction (IFC), National Building Information Model Standard (NBIMS), and other standards still have a long way to go, and the expansion of standards from the construction engineering field is also progressing slowly. Therefore, to pursue the application of BIM technology in the field of highway engineering or even the construction industry, comprehensive and feasible standard specifications should be formulated.

3.3. Difficulty of cross-stage information integration

From pre-decision-making to investigation and design, to construction management and lastly to the operation and maintenance stage, BIM has a good application prospect in the field of highway engineering, but the parties involved in the construction of BIM application at different stages have different concerns. There is a disconnect between the design-construction and the two major phases of the construction, how to effectively promote the transformation of the construction management model to break the traditional stage of the "information island" and "data," and "data integration," as well as breaking the "information silo" and "data barriers" between the traditional stages is crucial.

4. Development prospects of BIM technology in highway engineering

4.1. BIM design-construction integration

The first step of BIM design-construction integration is the analysis of information needs, in the understanding of the construction of the different concerns of all parties to the project, clear information is needed at each stage. According to the content of the demand, the data format will store different information according to the

pyramid format, from top to bottom, from new to old. Data that is more recent or used more frequently is placed on the top level of the table for easy extraction and use, and old data is placed in the lower level, until the last permanent storage table, the efficiency of data processing can be effectively improved through the conversion of old and new tables.

Next, the design unit needs to utilize the BIM + GIS platform as a tool to integrate the results of the design phase, and transfer the relevant data and information generated from the project decision-making to the construction, and operation and maintenance to ensure that all parties involved in the construction of the project can maintain efficient communication, but also to provide first-hand design documents for construction, and operation and maintenance phases. The construction unit should fully understand the designer's design intent, combined with the owner's comments, and subsequent operation unit needs to organize the construction program, part of the construction phase monitoring, and long-term monitoring, for the operation period of the operation, management, and maintenance work in order to provide convenience.

Lastly, a large amount of data will be generated during the management and construction process. The method to filter out information that can help different stages of design, construction, and post-operation is the focus of cross-stage integration. The collection path and the characteristics of different information should be analyzed to find the rules of summary processing.

4.2. Cross-stage information integration

The research and development and application of BIM + GIS construction information management system will provide a macro integration platform for the overall project for multiple participants, and each participant in the project can use the digital sand table to carry out practical applications in the following scenarios. The overall project overview browsing, construction program display, and engineering construction overall construction report can be achieved; the platform is used to realize research and discussion of part of the construction program; on-site analysis and evaluation of the positional relationship between the entire project and environmentally sensitive parts can be conducted.

BIM + GIS technology has a powerful data fusion function, which can be used to collect and summarize the data volume of the whole life cycle of highway engineering, but the data volume of the whole life cycle are massive, heterogeneous, and multi-source, and how to effectively divide the data and manage it scientifically requires the construction of a whole life cycle information storage platform based on BIM + GIS. At present, although the development of domestic BIM + GIS construction intelligence platform is in full swing, many of them are only cross-phase integrated storage of information, in which the information collection process lacks the BIM + GIS platform as a basis. The information collected in this way is difficult to play a role in project target control, therefore, BIM technology is integrated and penetrated into all aspects of the highway engineering construction process to achieve project-level full life cycle control, thus the BIM-based information collection methods need to be further researched.

5. Conclusion

The low degree of informatization of the whole life cycle of traditional highway engineering projects, the lack of electronic information, and the difficulty of accessing paper information are the major problems that restrict the intensive and intelligent development of engineering project management. With the in-depth development of BIM + GIS technology, a design-construction integrated information data storage platform is constructed. Through the BIM + GIS integrated information platform integration, this paper analyzed and put forward the difficulties in information integration, proposed a cross-stage information collection method, and realized the

design and construction based on the web side of the data integration, and built the design and construction of the integrated application based on the same data source.

In the future, during the operation phase of the project, the engineering data required during the operation and maintenance period can be extracted by means of the “data pump” of the BIM + GIS platform in order to carry out the overall digital handover of the project. Combined with the needs of inspection, maintenance, scheduling, and operation during the operation and maintenance period, various technical means such as Internet of Things (IoT) and Artificial Intelligence (AI) can be adopted to play a valuable role in project management.

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