Application of BIM + GIS Technology in Bridge Engineering Construction

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Abstract

First, the technical characteristics of BIM and GIS are analyzed, pointing out that the integration of BIM and GIS can provide a presentation form ranging from macro to micro for bridge construction process information management, better achieving the digitalization, informatization, and visualization of bridge construction processes, and further improving the management level of engineering project construction. Then, combined with requirement analysis for the bridge engineering construction phase, this paper adopts the C/S system architecture to implement three-dimensional digital management of bridge construction progress, quality, and cost based on BIM + GIS, applying database technology, bridge three-dimensional parametric modeling, and data sharing technology to bridge construction process management, achieving the transition from 3D-BIM to 5D-BIM in bridge construction processes, and providing managers with more effective decision support. Finally, the implementation effectiveness of engineering management informatization is analyzed, and the application prospects of BIM + GIS technology in engineering construction are pointed out.

Full Text

Application of BIM + GIS Technology in Bridge Engineering Construction

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Abstract This paper first analyzes the technical characteristics of BIM and GIS, and points out that the integration of BIM and GIS can present information management in the bridge construction process from the macro to the micro level, better realizing digitalized, informatized, and visualized construction of bridge construction processes, and further improving the construction management level of engineering projects. Then, in combination with the demand analysis of the bridge engineering construction stage, this paper adopts a C/S system architecture and realizes three-dimensional digital management of bridge construction progress, quality, and cost based on BIM + GIS. Database technology, three-dimensional parametric modeling of bridges, and data-sharing technology are applied to bridge construction process management, realizing the leap in bridge construction processes from 3D-BIM to 5D-BIM and providing managers with more effective decision-making support. Finally, the implementation effects of engineering management informatization are analyzed, and the application prospects of BIM + GIS technology in engineering construction are indicated.

[**Keywords**] BIM; GIS; bridge; construction management

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Introduction

The construction process of bridge engineering is complex and variable, and it is highly comprehensive. It is characterized by large investment, long cycles, and complex construction management. Therefore, information-based management of the bridge construction process is required in order to improve the efficiency and quality of engineering project management[1-3]. In the current construction management model, the storage and management of various types of information during bridge construction mainly rely on traditional static two-dimensional forms such as text, tables, and drawings. The transmission of such information is carried out in a very slow and isolated manner, and real-time control of construction information cannot be achieved[4]. As a result, this construction management model hinders the effective transmission and real-time sharing of information among all participants and reduces the efficiency of construction management.

With the rapid development of BIM technology in the construction industry, it has opened up a new path for informatized management of engineering projects. BIM uses all relevant information data of a construction project as the basis of the model to establish a building model, and simulates the real information possessed by the building through digital information simulation[5-8]. BIM has characteristics such as three-dimensional visualization, information collection, extraction, and collaboration, and is a new technology that promotes building informatization to a higher level. Applying BIM technology to the design, construction, and management of building engineering can significantly improve the efficiency of engineering construction and greatly reduce risks[9-10]. Liu Zhiming et al. applied BIM technology to the bridge design stage, realized visual presentation in the engineering project design stage, and effectively improved the efficiency of engineering design[11]. Xu Pingfei et al. used the advantages of BIM in parametrization and integration to integrate comprehensive management data with BIM model data, proposed a BIM-based engineering information management framework, and realized real-time sharing of engineering process data[12]. In the construction of the Honam high-speed railway in South Korea, BIM technology was applied to establish an integrated construction management system, realizing integrated on-site management[13]. Through previous studies, it can be found that informatized, digitalized, and visualized management of engineering projects can effectively improve the quality and efficiency of project management. At the same time, previous studies have mostly been based on BIM single-scale micro-models to carry out various engineering management tasks, and have failed to combine micro-scale information with macro-scale terrain or scenarios. Therefore, this paper introduces "BIM + GIS" technology into engineering information management. GIS technology is a container that

integrates spatial information; it is an information system that collects, stores, manages, comprehensively analyzes, and processes all information related to spatial information, and can be integrated with a variety of information analysis and processing technologies[14]. "BIM + GIS" technology meets the need to combine micro-level construction information with macro-level information. Therefore, studying a bridge construction management platform based on "BIM + GIS"technology and applying it to the construction stage of bridge engineering is of great significance.

1 Technical Characteristics of BIM and GIS

BIM technology is currently mainly applied to individual buildings, and its attribute information

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information can be refined to the component level, with many advantages such as a high degree of visualization, comprehensive building information, and good coordination. However, for relatively large transportation engineering projects, not only are road or bridge models required, but also the terrain model of the location and the surrounding macro-scale scenes. BIM technology has relatively weak macro-modeling capability, large model data volume, and long visualization preprocessing time[1]. After long-term research and application, GIS technology has a high degree of standardization and digitization and is relatively mature. It can integrate large-scale scene visual effects with geographic information analysis, facilitating correlation analysis between physical models and surrounding natural environments or terrain elements[2]. Therefore, GIS can assist BIM in building the geographic environmental scene around the model entity and improve the completeness of BIM model information.

BIM technology has major shortcomings in accurately determining geographic locations, analyzing spatial geographic information, and displaying the surrounding environment of structures. Three-dimensional GIS can complete geographic positioning and spatial analysis of structures and can more fully display large scenes, ensuring the integrity of information. Three-dimensional GIS is insufficient in terms of the model accuracy of the structure itself and cannot realize collision and quantity analysis within a building entity. The BIM model, however, integrates three-dimensional spatial information and building performance of bridge structures, helping to realize information transmission, information sharing, and collaborative work during bridge construction[3].

[1]Reference number visible on the page.
[2]Reference number visible on the page.
[3]Reference numbers visible on the page.

Therefore, both BIM and GIS technologies have advantages and deficiencies, and it is necessary to complement their strengths in bridge engineering construction. BIM is mainly used for analyzing and managing internal information of structures, while GIS is mainly used for managing regional space and analyzing spatial geographic information data. BIM model data and GIS geographic information data are stored in the cloud, enabling managers to remotely control the project.

2 BIM Demand Analysis in the Bridge Construction Stage

The management priorities in the bridge construction stage include project cost, progress, and quality management. Cost management is an enduring theme in bridge construction management. By integrating new BIM management technologies and adopting modern information-management methods, cost management can be strengthened, waste reduced to a minimum, costs saved, and higher benefits generated. Progress management is the core of ensuring that bridge construction projects are completed on time. By combining the characteristics of BIM, dynamic management of resource allocation can be realized, site layout can be reasonably planned, progress control can be strengthened, and the construction period can be ensured without delay. Quality management is a basic requirement of bridge project construction. By applying BIM technology and controlling materials layer by layer from the outset, a visualized construction site can be created so that all quality hazards have no place to hide; they can be prevented in advance, thereby ensuring project quality.

The BIM-based application system for construction-stage management includes the design stage 3D-BIM, 4D-BIM progress control, and 5D-BIM cost management.

The comprehensive application of BIM in highway construction enables the three mutually contradictory and interrelated aspects of "cost, progress, and quality" to reach a point of balance and develop in coordination. In BIM-based bridge project construction management, project cost can be effectively controlled, construction progress can be accelerated, and project quality can also be ensured.

3 Overall System Architecture Design

According to the system demand analysis, the system architecture is divided into a data layer, a service layer, and an application layer. The system architecture is shown in Figure 2.

The bottom layer of the system is the data layer, in which the GIS database includes the terrain data, image data, and other vector data required for the scene; three-

Figure 1 Demand Analysis for the Construction Stage

Figure 1. Demand analysis for the construction stage

Figure 1: Figure 1. Demand analysis for the construction stage

Figure 2 System architecture

Figure 2: Figure 2 System architecture

Fig. 2 System Architecture

The model database stores bridge BIM model data; the attribute database stores attribute data related to the model; the monitoring data mainly include monitoring data for bridges and pile foundations; the system database contains system management data such as role management, permission management, and system logs; other data include data such as two-dimensional drawings, inspection approval documents, and construction daily reports.

Data in the data layer, such as geographic information data, model data, and other business data, are published to the server to realize deployment of the service layer.

The system application layer mainly includes functions such as three-dimensional analysis, information management, schedule management, quality management, and cost management.

4 Implementation of System Functions

The system mainly implements functions such as three-dimensional analysis, scene roaming, information management, schedule management, quality management, and quantity statistics. The functional implementation process is shown in Fig. 3.

4.1 Three-Dimensional Analysis

The three-dimensional analysis function provides basic analytical functions for three-dimensional scenes, such as scene browsing, single-click query, spatial distance measurement, area measurement, terrain analysis, and viewshed analysis.

4.2 Schedule Management

Construction schedule management is a dynamic cyclic process composed of multiple links, including schedule planning, control, and coordination. By preparing the project schedule plan, the progress of the project is monitored within the established construction period. The actual progress is compared with the planned progress in real time and at regular intervals, deviations are detected as early as possible, the causes of the deviations and their degree of impact on the construction period are analyzed, corresponding measures are then taken, and the schedule plan is updated. The overall objective of schedule control is to

Figure 3 System implementation process

Figure 3: Figure 3 System implementation process

Figure 4 Entering the construction plan

Figure 4: Figure 4 Entering the construction plan

ensure that the established target construction period of the project is achieved, or, while guaranteeing schedule quality and without increasing actual costs as a result, to appropriately shorten the construction period.

Fig. 3 System Implementation Process

Fig. 4 Entering the Construction Plan

Figure 5. Three-dimensional visual progress display

Figure 6. Construction progress simulation

Figure 7. Progress comparison display

4.3 Quality Management

Quality management includes continuous girder alignment monitoring and bridge pile-foundation inspection, enabling real-time tracking of bridge quality.

(1) Construction alignment monitoring for continuous girders

This realizes real-time monitoring of each monitoring point of the continuous girder, including monitoring of data such as displacement, stress, and temperature, as well as display of the historical curves of each monitoring point.

Figure 8 Comparative display of linear inspection data

(2) Bridge pile-foundation inspection

Pile-foundation inspection mainly realizes implementation management of third-party pile-foundation quality inspection, including entry of inspection results, report uploading, display of pile-foundation quality categories, and labeling of categories with different colors. It also performs statistics on the completion status of bridge pile foundations and the proportions occupied by each category of pile foundation, thereby realizing information-based management of pile-foundation inspection.

Figure 9 Pile-foundation Inspection

Figure 5. Three-dimensional visual progress display

Figure 5: Figure 5. Three-dimensional visual progress display

Figure 6. Construction progress simulation

Figure 6: Figure 6. Construction progress simulation

Figure 7. Progress comparison display

Figure 7: Figure 7. Progress comparison display

4.4 Quantity Statistics

Quantity statistics are the basic basis for project valuation and also the core content of bridge design. Whether the calculation of quantities is accurate directly affects the accuracy of project cost estimation, as well as investment control in engineering construction. In bridge design quantity statistics, there are many design items and the calculation process is complex; therefore, it is necessary to adopt standardized methods for regulation and simplification.

This module mainly realizes engineering quantity statistics. The quantities of bridge construction works can be counted according to time or by subcontractor.

Figure 10 Quantity Statistics

5 Conclusion

Using bridge BIM models makes it possible to realize refined management of bridge engineering construction. Integrating GIS systems improves the ability of bridge engineering projects to analyze the spatial geographic environment and support spatial geographic information. Promoting the integration of BIM and GIS technologies is a necessary condition for the informatization and intelligentization of bridge construction. GIS technology is relatively mature in three-dimensional spatial applications, while BIM technology is still in its initial stage. The application of BIM + GIS platforms requires strengthening the standardization of data integration and the coordination of engineering operations. At present, conversion between BIM model data formats has been further optimized, but the degree of standardization still needs to be improved. Therefore, to raise the level of informatization in bridge construction, it is necessary to promote the integration of BIM and GIS technologies, ultimately improving construction safety and quality in traffic bridge construction and realizing informatized and visualized management of the process.

Figure 8. Comparative display of linear inspection data

Figure 8: Figure 8. Comparative display of linear inspection data

Figure 9. Pile-foundation inspection

Figure 9: Figure 9. Pile-foundation inspection

Figure 10. Quantity statistics

Figure 10: Figure 10. Quantity statistics

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Research on Applications of BIM + GIS Technology in Bridge Construction

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Abstract: This paper firstly analyzes technical characteristics of BIM and GIS, and points out that the combination of BIM and GIS can exhibit the bridge construction process for construction information management, from macroscopic way to microcosmic way. In this way, the bridge construction process can better achieve digitalization, informatization and visualization, which will greatly

Figure 1

Figure 11: Figure 1

Figure 2

Figure 12: Figure 2

promote the construction management level of engineering project. Then, considering the demand analysis of the bridge construction stage, this paper adopts the C/S system architecture to realize the 3D digital management base on BIM + GIS of bridge construction progress on the project schedule, quality and cost. The system applies database technology, 3D parametric modeling of bridge and data sharing technology in the bridge construction process management, and realizes a revolution from 3D-BIM to 5D-BIM application in bridge construction, which can offer stronger decision supports to the managers. Last, the implementation effect of project management informatization is analyzed in this paper, through which indicates the application prospect of BIM + GIS technology in bridge construction engineering.

Key Words: BIM Technology; GIS Technology; Bridge; Construction Management

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Figures

Figure 3

Figure 13: Figure 3

Figure 4

Figure 14: Figure 4

Figure 5

Figure 15: Figure 5

Figure 8

Figure 16: Figure 8

Figure 9

Figure 17: Figure 9

Figure 10

Figure 18: Figure 10

Figure 11

Figure 19: Figure 11