Proceedings of the 4th International Conference on Computing Innovation and Applied Physics
DOI: 10.54254/2753-8818/86/2025.20341

The Application of Building Information Modeling in Large Scale Railway Integrated Transportation Hubs

Juntong Kan[1,a,*]

[1]*Aulin College, Northeast Forestry University, Harbin, Heilongjiang, 150040, China*
a. 2258578633@qq.com
**corresponding author*

Abstract: In recent years, as the traditional construction industry has been upgraded, smart construction has emerged as a new direction for its development, and there has been a gradual increase in global attention to related technologies. BIM, as a bridge for the transformation and upgrading of the construction industry, and an indispensable tool in the construction process, its importance is self-evident. This article elaborates on the application of BIM in the constructing-scale railway comprehensive hubs from two aspects: basic application and combined application with related technologies (GIS, AI) through a literature review and case analysis. Regarding basic applications, BIM mainly participates in construction from four aspects: design, construction, maintenance, and management. In terms of combined applications, BIM primarily concentrates on integrating its advantages with other technologies, compensating for its shortcomings, and aiming to double its impact. In the future, BIM will increasingly focus on research that combines applications such as BIM+Internet of Things, BIM+green building, etc., providing technical support for future research in the smart construction industry related to BIM.

Keywords: Transportation, Railways, Construction

1. Introduction

Nowadays, based on technological innovation, policy support, and market demand, smart construction has gradually become an important direction for the transformation and upgrading of the construction industry. The continuous maturity and application of technologies, such as the Internet of Things, big data, and artificial intelligence, provide strong technical support for smart construction. The application of these technologies not only improves construction efficiency but also enhances the safety and intelligence level of buildings. BIM occupies an indispensable position among numerous technologies. Building information modeling (BIM) is the holistic process of creating and managing information for a built asset. Based on an intelligent model and enabled by a cloud platform, BIM integrates structured, multi-disciplinary data to produce a digital representation of an asset across its lifecycle, from planning and design to construction and operations[1]. Nowadays, a lot of large-scale railway comprehensive construction projects use this technology. Large-scale railway construction projects usually refer to projects with high investment, large scale, and profound impact on the national economy, and are directly approved and managed by the central government. These projects not only include the construction of ordinary railways but may also involve more efficient modes of transportation such as high-speed trains and subways.

DOI: 10.54254/2753-8818/86/2025.20341

The construction process is relatively complex, and the control of each link is very precise. Strict standards govern the selection of technologies, and this construction project fully incorporates BIM among many other technologies. There are currently related studies on BIM, such as Changsu Shim & HyounSeok Moon, which embark on a comprehensive exploration of the mainfold applications of BIM technologies across the spectrum of railway projects, spanning from initial design phases to subsequent maintenance operations[2]. Aaron Costin a, et al. present a literature review and critical analysis of BIM for transportation infrastructure[3]. This article provides a summary and analysis of case studies from previous research, highlighting the fundamental use of BIM in the construction of large-scale railway transportation hubs, as well as its integration with GIS and AI. This study has profound significance for the further extension and integration of BIM in the field of intelligent railway construction in the future.

2. Application based on BIM technology

2.1. Basic application of BIM

BIM can be viewed as a virtual process that encompasses all aspects, disciplines, and systems of a facility within a single, virtual model, allowing all design team members (owners, architects, engineers, contractors, subcontractors, and suppliers) to collaborate more accurately and efficiently than using traditional processes[4]. BIM technology represents a digitalized approach to architectural design, construction, and operation grounded in digital technology[5]. In particular, design, construction, maintenance, and administration are the four primary facets of the fundamental use of BIM.

In terms of design, BIM technology can be used in the design phase of construction projects, including construction budgeting, construction drawing design, construction processes, drafting, etc. It can help construction engineers quickly generate construction drawings, accurately capture all building requirements, detect potential design errors early, and swiftly redesign construction drawings. Furthermore, by simulating the construction process, BIM technology can significantly lower design and construction risks while assisting engineers and construction staff in identifying and resolving possible issues that may come up during the project.

In terms of construction, BIM technology makes construction in the field of civil engineering more efficient. It can improve work quality, reduce equipment and material waste, ensure correct allocation of equipment and materials, and play an important role in safety, ensuring the standard of safe operation and reducing the occurrence of unexpected situations during construction. At the same time, BIM technology can also improve the visibility of buildings, help users better analyze buildings, identify problems promptly, and better manage buildings.

In terms of maintenance, BIM technology can help the construction industry effectively maintain buildings. By using BIM, predictive maintenance can be achieved to ensure the long-term reliability of buildings. It can also provide best practices for the construction and maintenance of buildings, and promptly notify building maintenance personnel of information about building conditions, including new buildings, updated buildings, etc.

In terms of management, BIM technology can help managers timely detect defects in buildings (such as design conflicts, construction errors, operation and maintenance issues, etc.), as well as ensure the safe operation of buildings. By integrating various information from the processes of architectural design, construction, and operation management, visual management and optimization of the entire lifecycle of building projects can be achieved.

DOI: 10.54254/2753-8818/86/2025.20341

2.2. Case analysis

In terms of management, the underground section of Xiong'an New Area of Xiongxin High speed Railway has achieved full line and professional 3D model establishment, work unit data management, simulation demonstration, and coordinated services through the use of BIM technology, as well as effective supervision of quality, safety, progress, and personnel, thereby improving construction capacity and efficiency, ensuring project quality and management level. The Xiongxin High-speed Railway, also known as the Xiong'an New Area to Xinzhou High speed Railway, is located in the provinces of Hebei and Shanxi. The line, which is 342 kilometers long and has a planned speed of 350 kilometers per hour, begins at Xiong'an Station in the east and finishes at Xinzhou West Station in the west. The mileage range of the underground civil engineering project is from Xiongbao DK115+123.74 to Xiongbao DK139+962.18, with a total length of 24.838 kilometers. This includes the Daqing River Grand Bridge, Xiongbao Grand Bridge, Xiong'an No.1 Tunnel, No.2 Tunnel, No.3 Tunnel, Xiong'an Intercity Station, Xiaoli Station, and the starting section roadbed[6].

In the design phase, the first step was to establish a three-dimensional BIM model for the Xiongxin Railway project by adopting a unified BIM standard. This step provides a foundation for the subsequent construction phase, ensuring a seamless connection between design and construction; Secondly, through high-quality model design, a seamless transition from design to construction has been achieved, avoiding the need for construction units to rebuild models and improving work efficiency; By utilizing BIM models and 2D design results, a virtual simulation of this project has been completed, which helps to identify and solve potential problems before construction, reducing difficulties and costs in actual construction; By utilizing BIM technology, the traditional way of drawing review has been changed, and BIM-based drawing review has been carried out, improving the efficiency of drawing review and information transmission; The application of BIM technology has solved the problem of connection and collision between single disciplines, various disciplines, and projects within the area, fully leveraging the efficient collaboration of BIM.

By merging BIM models and 2D design outcomes data information, the fundamental ideas of "component management" as the object, "quality management" as the core, and "process management" as the beginning point are used during the building phase. Combined with 3D models as the display object, it ensures that all construction process information can be linked to tangible carriers, achieving full process management and collaborative application of data. Perform WBS (Work Breakdown Structure) decomposition on the first section of Xiong'an Tunnel No. 3, and determine the tunnel work breakdown structure tree; Create work unit instances based on work unit nodes, construction organization design, and construction plans. On the big business management platform, each work unit instance and its corresponding construction phase materials, progress, quality, cost, and safety data are linked, and the work unit data is used for project full process management, achieving one-time entry, global sharing, and eliminating duplicate entry, realizing project management data standardization, standardization institutionalization, institutional process, process automation, and continuous operation.

Through the application of BIM technology in the maintenance phase, the information and data flows between participating units have been effectively integrated, achieving precise presentation and coordination of spatial relationships. This provides high-level collaborative working conditions for complex on-road and off-road integrated projects, thus addressing the challenges of difficult construction and building management,

The application of BIM technology in the management phase also includes simulation demonstrations and coordination services. Real simulations are conducted through BIM models, such as energy-saving simulations, emergency evacuation simulations, sunlight simulations, thermal

DOI: 10.54254/2753-8818/86/2025.20341

energy conduction simulations, etc., as well as simulating actual construction based on the organizational design of the construction to determine a reasonable construction plan to guide the construction. Simultaneously, the coordination services of BIM can assist in managing conflicts between different disciplines, generating and providing coordination data, and minimizing waste and project delays.

3. Application combined with BIM technology

With the rapid development of intelligent construction, the application of BIM is no longer limited to its functions. Its combination with other technologies is also widely used in large-scale railway construction and other building construction, such as BIM+GIS (Geographic Information System), BIM+AI, BIM+Internet of Things, BIM+cloud computing, etc. This article takes BIM+GIS and BIM+AI technologies as examples to specifically explain the integration and application process.

3.1. BIM+GIS

Building information modeling (BIM) and geographical information systems (GIS) provide digital representation of architectural and environmental entities. BIM focuses on the micro-level representation of buildings themselves, and GIS provides a macro-level representation of the external environments of buildings[7]. The integration of BIM and GIS is a trend, and their complementary advantages can bring more efficient project management and decision support. The integration of BIM and GIS is mainly achieved through data integration, system integration, or application integration, aiming to leverage their respective advantages and expand their application areas. While GIS offers a macro-level description of the external environments of buildings, BIM concentrates on the micro-level depiction of buildings themselves. GIS focuses on the processing of geographic information, including the integration of spatial backgrounds such as terrain, streets, and transportation. The fusion of the two can achieve the following goals:

Data fusion: By combining the three-dimensional visibility of BIM models with the spatial background of GIS such as location, terrain, streets, and traffic, comprehensive physical attributes and functional information are provided. This integration not only improves the accuracy and depth of building information modeling but also provides technical support for building information management.

Information sharing and collaboration: The combination of BIM and GIS can achieve information sharing and collaborative work among multiple departments and specialties, helping to break down information silos and improve the efficiency and quality of project management.

Improving analysis efficiency: By combining the geographic spatial analysis capabilities of GIS and the building information management capabilities of BIM, in-depth analysis of project spatial layout, traffic flow, environmental impact, etc. can be conducted, providing strong support for project decision-making.

Emergency management and disaster prevention and reduction: In emergencies, the combination of BIM and GIS can enhance emergency management and disaster prevention and reduction capabilities, providing rapid response and decision support.

The methods for integrating BIM and GIS include:

Data conversion: To enable information sharing between the two models, convert GIS data into building models or BIM model information into GIS data.

Data exchange and information sharing: Through standards such as IFC protocol and CityGML, data exchange is carried out to achieve effective utilization of spatial resources.

By using spatial database technology, real-time GIS and BIM data sharing is made possible and the natural integration of GIS and BIM model information is made possible.

DOI: 10.54254/2753-8818/86/2025.20341

3.2. BIM+AI

The motivation behind BIM-AI integration is to maximize great value from both BIM and AI, which creates the possibility of easily getting great access to available information and automatically bringing deep insights into a complex project with less manual work. Therefore, the combination of these two powerful technologies is bound to grow in the future, which can act as a digital assistant to improve the productivity, quality, and safety of construction projects[8]. BIM technology simulates the design, construction, and maintenance processes of buildings by creating three-dimensional models, while AI provides decision support through data analysis and intelligent algorithms. This combination not only improves the efficiency and quality of the project but also enhances its sustainability in large-scale railway construction.

The application of BIM+AI is mainly reflected in the following aspects: engineering quantity calculation: By using AI and BIM technology, the automation and intelligence of engineering quantity calculation can be achieved, improving the accuracy and efficiency of calculation, reducing labor input and costs. Design optimization: It can automatically detect potential problems in the design, optimize the design scheme, and reduce design errors and modifications. Construction management: BIM models can simulate construction, detect potential problems in advance, optimize construction plans, and ensure smooth construction. Quality control: AI can monitor construction quality in real time through data analysis, ensuring the standardization and accuracy of the construction process. Safety management: By using smart wearable devices and sensors, real-time monitoring of construction site safety conditions can be achieved, reducing the risk of accidents

3.3. Case analysis

The Beijing Xiong'an Intercity Railway is an intercity railway in China that connects Beijing with Xiong'an New Area in Hebei Province. It is a crucial railway route for enhancing the Beijing, Tianjin, and Hebei region's high-speed rail network architecture. The Beijing Xiong'an Intercity Railway, which has six stations (five of which are for passenger services) and a total length of 91 kilometers, connects Liying Station to Xiong'an Station as of December 2020. The designed speed is 250 kilometers per hour (Li Da section) and 350 kilometers per hour (Daxiong section). For the first time in the construction process, the entire line and process were fully utilized, and BIM technology was applied in all specialties for design, achieving breakthroughs. The construction process fully utilizes the combination of BIM and GIS technology. By utilizing BIM+GIS technology, a comprehensive database for the construction management of the Beijing Xiongnu intercity railway is formed by integrating 3D design information, surrounding environmental information, and on-site construction data. Standard data modules are classified based on business levels (leadership, execution), job settings (engineering department, safety and quality department, material department, planning and finance department, comprehensive department), and management dimensions (schedule, cost, quality, safety, investment) to provide guidance and basis for construction management[9].

The application of BIM+GIS technology in the construction management process is mainly reflected in the following aspects:

Data integration and visualization: Through BIM+GIS technology, the Beijing Xiongnu intercity railway has achieved the fusion and display of massive multi-source, multi-topic, heterogeneous spatiotemporal data, including BIM models, oblique photography models, and engineering construction information. These data are integrated on one map, meeting the lean needs of different management departments and users at different levels for 3D visualization, digitization, and all element information construction management. Establishing display standards for models and information at various scales, producing multi-dimensional visual data views, enabling quick switching between macro, meso, and micro levels, and facilitating organic transitions between interior and outdoor spaces are all made possible by BIM+GIS technology.

Platform design and application: A platform based on private cloud and public end has been built, which takes BIM data as the core, integrates technologies such as the Internet of Things, big data, and cloud storage, and controls the entire life cycle of the construction process through models and engineering data, achieving the integration of information in various stages of construction.

Design and Optimization: In the feasibility study and preliminary design stages, geographic and geological models were established, and the virtual survey was carried out using 3D GIS functions to assist in scheme design. In the construction drawing design phase, a three-dimensional visualization scene of the entire line was established, achieving a detailed display of the terrain, landforms, and railway facilities and equipment within a range of 200 meters on both sides of the line.

Through these applications, the Beijing Xiongnu intercity railway not only improves the efficiency and quality of construction management but also plays a typical demonstration role in the informatization and intelligent construction of railway engineering.

4. Discussion

At present, the application of BIM technology in large-scale railway construction has achieved significant results, not only improving the intelligence level of railway construction but also promoting the progress of related technologies and standards, providing strong support for the modernization and intelligence of railway construction. Not only does it fully utilize its engineering capabilities, but its integration with other technologies is also widely used in large-scale railway construction and other related fields. Although the application of BIM technology in large-scale railway construction has made some progress, it still faces some challenges and limitations. With the advancement of digital transformation, the application scope of BIM technology continues to expand, and the market size continues to grow. BIM-savvy people will be in high demand, and the projected supply/demand equation will place acute pressure on the industry to acquire or cultivate competent BIM talent to increase knowledge-worker productivity across the industry to meet the rising demand[10]. Therefore, the lack of technical and management talents is the main problem in BIM talent cultivation.

5. Conclusion

This article elaborates on the application of BIM in the constructingge-scale railway comprehensive hubs from two aspects. Through literature search and case analysis, it illustrates the application of BIM in both basic and combined applications. In terms of basic applications, BIM mainly participates in construction from four aspects: design, construction, maintenance, and management. By combining its benefits with other technologies and compensating for its drawbacks, BIM focuses more on technology integration in terms of combined applications, so doubling the effect. Nevertheless, the summary still has certain flaws because of the absence of data support. In the future, retrieval and summarization can be achieved through data models.

References

[1] What Is BIM | Building Information Modeling | Autodesk? (2023, August 8). Autodesk.com. https://www.autodesk.com/solutions/aec/bim?msockid=043737acf0776c833c5623eaf1116d4c

[2] Shim, C., & Moon, H. (2024). Recent BIM Developments and Applications on Railway Infrastructure. 211–227. https://doi.org/10.1007/978-3-031-49589-2_11

[3] *Costin, A., Adibfar, A., Hu, H., & Chen, S. S. (2018). Building Information Modeling (BIM) for transportation infrastructure – Literature review, applications, challenges, and recommendations. Automation in Construction, 94, 257–281. https://doi.org/10.1016/j.autcon.2018.07.001*

[4] *Azhar, S. (2011). Building Information Modeling (BIM): Trends, Benefits, Risks, and Challenges for the AEC Industry. Leadership and Management in Engineering, 11(3), 241–252. ascelibrary. https://doi.org/10.1061/(ASCE)lm.1943-5630.0000127*

[5] *Zhou, D., Pei, B., Li, X., Jiang, D., & Wen, L. (2024). Innovative BIM technology application in the construction management of highways. Scientific Reports, 14(1), 15298. https://doi.org/10.1038/s41598-024-66232-5*

[6] *Bilibili.com. https://www.bilibili.com/read/cv35706541/ Rail Transit Technology Observation Room. (2024). Application of BIM Technology in Civil Engineering of Xiong'an New Area Underground Section of Xiongxin High speed Railway - China Railway Fourth Bureau*

[7] *Wang, H., Pan, Y., & Luo, X. (2019). Integration of BIM and GIS in sustainable built environment: A review and bibliometric analysis. Automation in Construction, 103, 41–52. https://doi.org/10.1016/j.autcon.2019.03.005*

[8] *Pan, Y., & Zhang, L. (2022). Integrating BIM and AI for Smart Construction Management: Current Status and Future Directions. Archives of Computational Methods in Engineering, 30. https://doi.org/10.1007/s11831-022-09830-8*

[9] *The application of intelligent construction technology in the Beijing Xiongnu intercity railway - Wuhan Urban Construction Bureau. (2023). Wuhan.gov.cn. https://cjw.wuhan.gov.cn/ztzl_30486/znzjzl/znjzgzdt/202310/t20231023_2284493.html*

[10] *Wu, W., & Issa, R. R. A.. (2013). IMPACTS OF BIM ON TALENT ACQUISITION IN THE CONSTRUCTION INDUSTRY. 29th Annual ARCOM Conference.*