Journal of World Architecture, 2025, Volume 9, Issue 6
https://ojs.bbwpublisher.com/index.php/JWA
Online ISSN: 2208-3499
Print ISSN: 2208-3480

BIM Technology Leads the Digital Transformation of the Construction Industry

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Abstract: Against the backdrop of digital transformation in the global construction industry, BIM technology serves as the core driving force. By building a unified data standard and intelligent review system, it promotes the digital transformation of the entire process and all elements in the construction industry. This article systematically analyzes the development path of digital architecture at home and abroad, explores the key technology system of intelligent construction, summarizes the digital practices in planning, design, construction implementation, and operation and maintenance stages, and provides theoretical support and practical reference for building a modern architecture industry system.

Keywords: Building Information Modeling (BIM); Intelligent construction; Digital transformation

Online publication: December 31, 2025

1. Introduction

Against the backdrop of the global construction industry moving towards intelligence and greenness, digital transformation has become the core driving force for industrial upgrading. Building Information Modeling (BIM) technology, as a key carrier for achieving digital management of the entire lifecycle of buildings, is profoundly changing the traditional construction model. In October 2022, the Ministry of Housing and Urban Rural Development issued a notice on the announcement of pilot cities for intelligent construction (Jian [2022] No. 82), launching intelligent construction pilot projects in 24 cities across the country, marking the entry of China's construction industry into a systematic promotion stage of digital transformation. BIM technology provides full process digital support for engineering design, review, construction, and operation and maintenance by unifying data standards, integrating and collaborating multiple sources of information, and becoming an important technical foundation for building a modern construction industry system. Promoting the deep application and systematic development of BIM technology is of great strategic significance for improving engineering quality and promoting high-quality development of the industry.

1.1. Overview of BIM technology and its significance in the digital transformation of the construction industry

1.1.1. Basic connotation and development history of BIM technology

BIM technology is a digital representation and management method that covers the entire life cycle of a building. Its core lies in integrating geometric information and non-geometric information such as physical and functional attributes of a project through parameterized models, forming a shared knowledge resource. BIM is not only a 3D modeling tool, but also a process oriented collaborative work mode that provides decision-making basis for all parties involved in the project. This technology originated from the concept of computer-aided design in the 1970s, and by the early 21st century, with the maturity of the data exchange standard IFC and the improvement of computer computing power, it gradually developed from a simple visual display to an information management platform that integrates design, construction, and operation.

Since BIM was included in China's 12th Five Year Plan in 2011, the industry has experienced rapid development from concept popularization to practical application. Relevant national standards and policy guidance have been successively issued, marking a new stage of BIM technology from local application to industry wide integration and standardization development. In engineering practice, the cost management method based on BIM technology has demonstrated significant advantages in infrastructure projects such as tunnels, providing effective support for the refined management of the entire project process [1].

1.1.2. The role of BIM technology in promoting intelligence and digitization in the construction industry

BIM technology, as the core engine of digital transformation in the construction industry, has profoundly changed traditional work paradigms and management processes. It creates and maintains a consistent digital model throughout the entire project process, providing a unified and reliable data foundation for design collaboration, construction simulation, and operation and maintenance management. It is the key to achieving refined project management and scientific decision-making. By promoting seamless data transmission and integration across design, construction, and operation stages, BIM technology effectively eliminates information silos and promotes cross disciplinary and cross stage business collaboration.

At the level of intelligence, structured data based on BIM models is a prerequisite for driving advanced applications such as automated review, performance simulation analysis, and intelligent operation and maintenance. As an important part of project implementation, the digital transformation and automated execution of review standards for construction project planning and acceptance have become a focus of industry attention [2]. The in-depth application of this technology not only improves the quality and efficiency of engineering, but also gives birth to new digital business forms and management models, laying a solid foundation for building a modern construction industry system.

2. Comparative study on the digitalization process of the global construction industry

2.1. Experience of building digital governance system construction in developed countries

Developed countries have formed a relatively complete system architecture in digital governance of buildings, and their core experience lies in government led standardization construction and institutional innovation. The UK has taken the lead in building a nationwide digital review framework by mandating 3D-BIM collaboration and establishing a digital center CDDB. The ByggSok system led by Statsbygg in Norway converts building codes into machine-readable rules, achieving an automated approval process based on IFC standards [3]. Its SIMBA delivery standard provides institutional guarantees for data exchange. Sweden is committed to building an integrated business management system, moving towards the goal of "one click approval" by automatically matching regulatory provisions with BIM models. The usBIM platform in Italy and the Lupapiste system in Finland both demonstrate the advantages of open BIM standards in improving approval efficiency (**Figure 1** and **Figure 2**). The practices of these countries collectively demonstrate that establishing a unified data standard, promoting the digitization of regulatory provisions, and building an open and shared collaborative platform are key paths to enhancing industry digital governance capabilities.

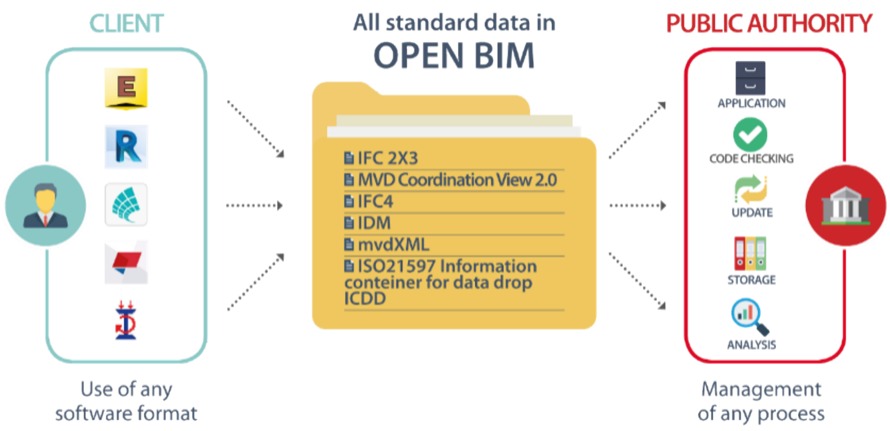

Figure 1. Experience of building digital governance system construction in developed countries: Italy achieves data exchange for different needs through open formats.

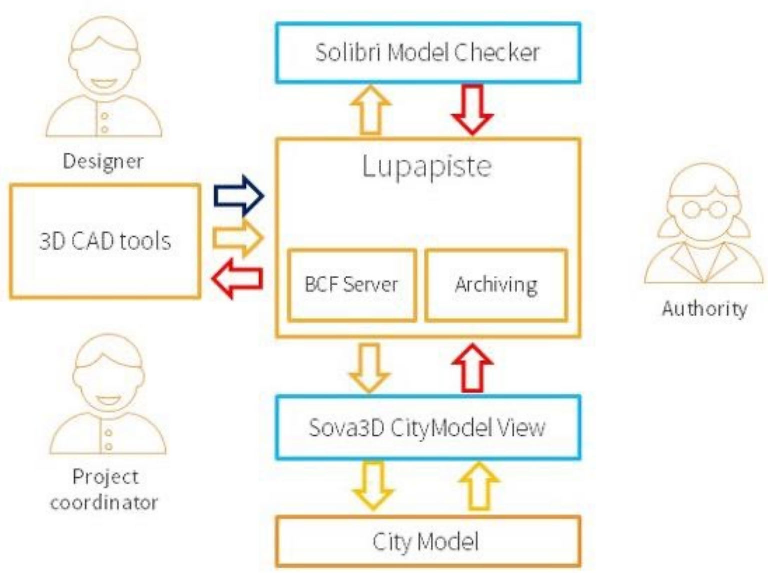

Figure 2. Experience of building digital governance system construction in developed countries: The testing, approval, interaction, and archiving process of the Lupapiste project in Finland.

2.2. Stage characteristics and regional practices of digital development in China's construction industry

The digital development of China's construction industry presents typical characteristics of policy driven, regional pilot, and gradual deepening. Since BIM technology was included in the 12th Five Year Plan, the industry has undergone a transformation from concept introduction to practical application. The Ministry of Housing and Urban Rural Development has established the strategic position of BIM technology in engineering construction by issuing policy documents such as the Guiding Opinions on Promoting the Application of Building Information Modeling.

The practice and exploration in various regions have formed diversified development models as follows:

(1) Hunan Province took the lead in establishing a BIM review system and standardized the review process by converting the model into XDB format;

(2) Xiamen has established a CIM platform through the "multi regulation integration" reform, realizing the application of BIM in the planning and approval stage;

(3) Guangzhou is committed to building a CIM platform system that covers the entire lifecycle. The successful application of BIM technology in infrastructure construction such as road renovation provides important practical references for the digital transformation of the industry [4].

Although these regional practices have achieved significant results, they still face challenges in terms of data standard openness and system automation, reflecting that China's building digitalization process is in a critical stage of transitioning from local breakthroughs to system integration.

3. Construction of key technology system

3.1. Standardization of building data and information governance framework

3.1.1. Multi source data fusion and collaborative management

Multi source data fusion and collaborative management are the cornerstone of building an intelligent construction technology system. In the entire lifecycle of engineering projects, the data generated in the design, construction, operation and maintenance stages has multi-source heterogeneous characteristics, covering various types such as geometric information, attribute parameters, business rules, etc. Establishing a unified data standard system has become the key to achieving effective data integration, which requires clear technical requirements such as object classification and coding rules, attribute parameter definitions, and data exchange formats.

By building a data processing platform based on cloud native architecture, standardized parsing and conversion of data from different modeling software such as Revit and Archicad can be achieved, eliminating information silos. The data collaborative management mechanism requires the establishment of supporting systems such as version control, permission management, and process traceability to ensure cross stage and cross disciplinary data consistency and integrity. BIM technology has demonstrated excellent data collaborative management capabilities in industrial construction projects such as material yard closure engineering, providing important references for the digital implementation of similar projects [5]. This collaborative management model provides a high-quality data foundation for subsequent intelligent review and analysis.

3.1.2. Semantic data structures and knowledge representation

Semantic data structure and knowledge representation are key technologies for enhancing the intelligent processing capability of building data. Traditional BIM data storage often uses relational databases or IFC file formats, which have limitations in expressing complex relationships and attribute semantics between components. By introducing knowledge graph technology, the components, attributes, and their interrelationships in BIM models can be transformed into a triplet representation of "entity relationship attribute", which can more accurately capture the semantic information of building elements. In professional engineering such as water supply and drainage systems, semantic based technical methods can effectively express professional attributes such as pipeline connection relationships and water flow directions, improving the compliance and rationality of design schemes [6].

This ontology based knowledge representation method provides a structured foundation for component classification, relational reasoning, and rule checking. The graph based storage solution supports efficient graph traversal queries, facilitating semantic based scene recognition and sub model extraction, providing technical support for complex rule matching and inference analysis in intelligent review, significantly improving the usability value and intelligent application level of building data.

3.2. Intelligent review technology methods and implementation paths

3.2.1. Machine readable conversion mechanism for standardized articles

The machine-readable conversion of normative provisions is a fundamental step in achieving intelligent review. Traditional building codes are expressed in natural language and are difficult to be directly recognized and processed by computer systems. The use of Structured Naming Language (SNL) to formally describe normative provisions and convert textual clauses into computer executable logical rules is an effective way to solve this problem. The conversion process requires collaboration between domain experts and technical personnel to accurately analyze the constraints, parameter requirements, and logical relationships in the text, forming standardized rule expressions.

The engineering specification description language based on SNL can accurately define component attribute requirements, spatial relationship constraints, and performance index limitations, providing a structured rule library for subsequent automated reviews. The integrated development of "BIM+" technology provides a new technological path for the digital transformation of normative provisions and promotes the intelligent transformation of the review process [7]. This machine-readable rule expression not only retains the technical connotation of the text, but also achieves the computability of the review rules through a unified syntax structure, laying a solid foundation for the inference and judgment of the rule engine.

3.2.2. Intelligent recognition and decision support for review scenarios

Intelligent recognition of review scenarios is the core technology for improving review efficiency. By constructing a scene feature library based on knowledge graph, the system can automatically identify typical review scenes in the model and classify and annotate them. This technology utilizes the spatial topological relationships and attribute features between components to extract scene features related to review rules in advance, forming an association network of scene component attribute. The advantages of GIS technology in spatial data analysis provide important technical support for intelligent recognition of review scenarios, especially in handling spatial relationships of construction land, which has unique value [8].

After the model is uploaded, the system quickly locates component combinations that meet specific review criteria through graph traversal algorithms, greatly reducing the computational cost of traversing the entire model. The scene pre recognition mechanism based on distributed computing enables the review process to focus on relevant areas, significantly improving processing efficiency. At the same time, the system displays the relationship path between the review results and the problem components through a visual interface, providing clear decision-making basis for reviewers and achieving a mode transition from passive inspection to active recognition, effectively supporting the scientific and accurate nature of review decisions.

4. Application and efficiency enhancement of digital practice

4.1. Innovation in digital review during the planning and design phase

4.1.1. Refactoring and efficiency improvement of construction approval process

The traditional construction application approval process has the problems of cumbersome links and lengthy cycles, and digital review technology promotes fundamental restructuring of the approval process. The BIM based construction application system transforms the previously serial multi department review into parallel processing, and achieves synchronous review among departments through a unified data standard and shared platform. The integration of blockchain and electronic signature technology further enhances the security and credibility of the approval process, ensuring the integrity and immutability of data during transmission and storage [9].

The system uses model lightweight technology and cloud rendering engine to support reviewers to directly browse 3D models and annotate them on the browser, greatly reducing offline communication and drawing printing costs. The practice of BIM review system in Hunan Province shows that after adopting digital construction application, the approval cycle can be shortened by about 40%, and the work efficiency of reviewers can be significantly improved. This process reengineering is not only reflected in time compression, but also reduces the burden of repeatedly modifying drawings for construction units through standardized data interfaces and automated format conversion, forming a more transparent and efficient approval environment.

4.1.2. Compliance intelligent verification and decision optimization

Compliance intelligent verification transforms the traditional manual experience based technical review into a rule-based automated detection process. The system uses a rule engine to parse mandatory clauses in building codes and automatically checks key technical indicators such as fire separation distance, sunlight analysis, and plot ratio in BIM models. In the field of water conservancy engineering planning and design, the application of BIM technology has demonstrated unique advantages in conducting compliance analysis under complex terrain conditions, providing important references for digital review of similar projects [10].

The operational data of a certain BIM approval platform shows that automated review can identify about 80% of routine compliance issues, greatly reducing the basic workload of reviewers. At the level of decision optimization, the system clearly identifies the violating components and their specific terms through visualization, assisting reviewers in quickly identifying the essence of the problem. Meanwhile, the case library constructed based on historical review data provides disposal references for similar issues, forming a continuously optimized decision support mechanism. This intelligent verification not only improves the accuracy of review, but also reduces subjective differences in human judgment through standardized processing procedures, making approval decisions more scientific and standardized.

4.2. Breakthrough in digital supervision during construction implementation phase

4.2.1. Reconstruction of the whole process quality and safety control system

Traditional quality and safety management relies on manual inspections and paper records, which have limitations such as low efficiency and outdated information. BIM technology is deeply integrated with technologies such as the Internet of Things and mobile communication, promoting the reconstruction of the quality and safety management system towards digitization and intelligence. By linking the construction BIM model with the schedule, quality acceptance standards, and safety regulations, a digital management chain covering the entire process of scheme simulation, technical disclosure, process inspection, and acceptance evaluation is constructed.

On site management personnel use mobile terminals to collect construction data in real-time, and the system automatically compares deviations between actual construction and model design, issuing quality warnings in a timely manner. In terms of safety supervision, model-based hazard identification and protection facility planning, combined with video intelligent analysis technology, have achieved automatic monitoring and early warning of high-risk operations. This restructured control system has formed a closed-loop management mechanism of “pre prevention, in-process control, and post traceability”, significantly improving the reliability of engineering quality and the safety level of construction sites.

4.2.2. Digital delivery and collaborative mechanism innovation

The digital delivery during the construction phase has broken the traditional paper-based delivery model and established a full process data delivery mechanism based on BIM models. This mechanism requires all participating units to create and update models based on a unified BIM standard, ensuring accurate transmission of design intent to the construction process. Through the cloud collaboration platform, design changes can be synchronized in real-time to the construction model, avoiding rework and waste caused by inconsistent information. The completion drawing digital filing system built on the CIM platform in Guangzhou has achieved data connectivity throughout the entire process from design to completion, providing complete digital assets for subsequent operation and maintenance stages. This collaborative mechanism not only improves the efficiency of collaboration between various professions, but also ensures the consistency between the completed model and the physical building through standardized data exchange formats and structured information organization, laying a solid foundation for the full lifecycle management of buildings.

4.3. Digital empowerment during the operation and maintenance phase

4.3.1. Construction of urban level digital twin infrastructure

The construction of urban level digital twins is based on the CIM platform as the core carrier, integrating geographic information systems, building information models, and IoT perception data to form a virtual real mapping urban digital floor. The practice of Xiamen’s “multi regulation integration” CIM platform has shown that by aggregating current, planning, and operational data, it is possible to achieve the integrated expression and management of urban spatial resources in two and three dimensions. This foundation dynamically updates the approved BIM model to the city information model, supporting multi-scale visualization display and analysis from individual buildings to urban areas. A digital twin system based on a unified spatial coordinate system can integrate real-time operational data such as municipal facilities, traffic flow, and environmental monitoring, providing a decision support environment for urban governance with full domain perception and dynamic simulation, promoting the transformation of urban management from passive response to active prediction, and providing indispensable digital infrastructure for smart city construction.

4.3.2. Full lifecycle data value mining

The deep mining of the value of building lifecycle data relies on a complete data chain from planning and design to operation and maintenance. As a data carrier that runs through all stages, BIM models contain geometric information, attribute parameters, and business data that are stored in a structured and semantically processed manner, forming traceable and analyzable digital assets. Based on knowledge graph technology, data association analysis can identify potential value points such as equipment operation patterns and space utilization efficiency, supporting preventive maintenance and energy consumption optimization strategy formulation. By analyzing historical operation and maintenance data through machine learning algorithms, a performance prediction model for facility equipment can be established, significantly improving the accuracy and economy of operation and maintenance management. This data-driven decision-making model fully unleashes the potential value of building lifecycle data, promotes the transformation of operation and maintenance management from experience driven to data-driven, and achieves continuous improvement and optimization of building asset value.

5. Conclusion

The digital transformation of the construction industry is undergoing a profound transformation from the application of technological tools to systematic restructuring. BIM technology, as the core driving force, has significantly improved the quality and efficiency of engineering construction by establishing a unified data standard system and intelligent review mechanism. A comparative study of the global digitalization process in architecture shows that developed countries have formed systematic experience in standardized construction and institutional innovation, while China has explored a development path that is in line with its national conditions through regional pilot projects. The construction of key technology systems for intelligent construction, especially breakthroughs in data standardization governance and intelligent review methods, provides a solid technical foundation for the digital transformation of the industry. The full process application of BIM technology, from process reengineering in the planning and design stage, to digital supervision in the construction implementation stage, and to intelligent empowerment in the operation and maintenance stage, is reshaping the operation mode of the construction industry. In future development, it is necessary to further strengthen the openness and interoperability of data standards, deepen the integration and innovation of BIM with technologies such as the Internet of Things and artificial intelligence, improve the full lifecycle management mechanism based on digital twins, promote the establishment of a collaborative and shared industry ecosystem, and ultimately achieve the modernization and upgrading of the construction industry system.

Disclosure statement

The author declares no conflict of interest.

References

[1] Zhu M, 2023, Application Research on Cost Management of XY Tunnel Project Based on BIM Technology, thesis, Hebei University of Geosciences.

[2] Qin J, 2021, Judicial Review of Construction Project Planning Acceptance Behavior, thesis, Soochow University.

[3] Zhang X, 2021, Application Research on Computational BIM Technology in Architectural Design Compliance Review, thesis, Qingdao University of Technology.

[4] Bai R, 2021, Application Research on BIM Technology in Road Reconstruction and Upgrading Project Construction,

thesis, Inner Mongolia University of Technology.

[5] Liu X, 2023, Application Research on BIM Technology in Material Yard Enclosure Project, thesis, Shenyang Jianzhu University.

[6] Ge T, 2024, Application Research on BIM Technology in High-Rise Building Water Supply and Drainage Design. Brick and Tile World, 2024(10): 142–144.

[7] Jiang M, 2023, Exploration and Research on the Application of “BIM+” Technology in the Engineering Construction Industry. Green Building, 15(2): 11–12.

[8] Guo J, 2023, County-Level Construction Land Review and Approval System based on GIS Technology. China Science and Technology Information, 2023(24): 64–67.

[9] Wu W, Luo L, He X, et al., 2022, Design of Construction Project Planning and Approval System based on Blockchain + Electronic Signature Technology. Modern Information Technology, 6(23): 7–10.

[10] Huang X, Li Z, 2021, Application of BIM Technology in Water Conservancy Project Planning and Design. China Resources Comprehensive Utilization, 39(2): 23–24.

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