BIM Technology-Based Collaborative Management in Construction Projects

Zixuan Tang, Qian Zhang*
School of Civil and Architectural Engineering, Panzhihua University, Panzhihua, China
**Corresponding author*

Abstract: Construction projects have the characteristics of multiple stakeholders, long construction periods, and complexity of multiple disciplines, making it difficult to achieve efficient collaboration through conventional remediation methods. With the rapid development of BIM technology, new ideas have been provided for collaborative management. This article comprehensively studies three modes: central document based cooperation, cloud platform based cooperation, CDE platform based cooperation, as well as their application status in various stages such as design, construction, and operation. Secondly, this article comprehensively analyzes the development status of private enterprises in China from the aspects of institutional mechanisms, talent skills, interest coordination, and technological investment. Therefore, the project will conduct in-depth research from four aspects: unified data standards, clear division of responsibilities, optimized platform integration, and strengthened talent training, aiming to lay the foundation for the development and application of information technology in construction engineering.

Keywords: BIM; Construction Projects; Collaborative Management; Information Sharing

1. Introduction

Architectural projects involve multiple stakeholders and disciplines, yet current paper-based information systems suffer from isolated data silos, delayed interactions, and coordination difficulties. With the continual expansion of national key projects, the demand for enhanced project quality and efficiency intensifies, necessitating the adoption of innovative technologies and methodologies to elevate collaborative synergy.

The advent of Building Information Modeling (BIM) technology has profoundly transformed the operational paradigm of construction enterprises [1]. By integrating geometric, physical, and functional data, this technology establishes a robust foundation for information sharing and cooperative efforts throughout the construction process. China is actively promoting related initiatives; the 2016-2020 Construction Industry Informatization Development Outline explicitly calls for the acceleration of comprehensive BIM integration across project lifecycles to drive informatization and intelligentization within the construction sector.

In practice, information technology has evolved from single-discipline applications to multi-disciplinary collaboration. However, many projects lack standardized management frameworks and exhibit irregular BIM applications. The construction industry urgently needs to dismantle information barriers spanning design, construction, and operation phases, and to develop efficient, standardized BIM collaborative management models.

This study holds significant theoretical and practical implications. Theoretically, it systematically delineates BIM collaboration modalities, elucidating the characteristics and applicability of centralized document-based collaboration, cloud platform collaboration, and collaborative working environments. It furnishes foundational support for the establishment of BIM collaboration frameworks and facilitates the transformation from “experience-based” to “data-driven” multi-stakeholder coordination mechanisms. Practically, by addressing data standardization, responsibility allocation, and platform integration, it enhances data sharing and policy coordination among project participants, elevates project management efficacy, reduces design alterations and construction conflicts, shortens timelines, and lowers maintenance costs. Consequently, it offers invaluable data support for subsequent operational management, playing a crucial role in the advancement of engineering operation and maintenance practices in China.

2. Current Status of Collaborative Management in Architectural Engineering Projects Based on BIM Technology

2.1 Present Collaborative Management Models

2.1.1 Centralized document-based collaboration

This model utilizes distributed file collaboration technology to create a shared BIM data repository, facilitating more effective data sharing among project participants [2]. Different professional teams simultaneously access a common central model, each focusing on their respective responsibilities. They update their segments in the central repository, allowing seamless use of the latest information by all parties. This approach is especially suitable for projects with clearly defined tasks and relatively small teams, such as medium-sized public buildings.

A classic tool exemplifying this centralized collaboration is Autodesk Revit's Worksharing feature [3]. Here, the project manager assigns tasks that individuals save locally and regularly synchronize with the central model to maintain up-to-date data consistency. This method thrives in stable network environments with dense team collaboration, ensuring data uniqueness and preventing confusion arising from multiple file versions.

Currently, many design institutes and BIM consulting firms predominantly collaborate through this “central document” approach, particularly in early model development stages. Although it demands substantial server resources, this method supports a relatively comprehensive business standard and workflow, forming a foundational BIM collaboration framework for inter-organizational coordination.

2.1.2 Cloud platform-based collaboration

Cloud computing has ushered in a rapidly advancing collaborative BIM paradigm by enabling real-time cooperation across various geographical and organizational boundaries. Prominent cloud platforms include Autodesk BIM 360, Trimble Connect, Glodon BIMCloud, and Sweco’s cloud collaboration system.

Practically, cloud-based collaboration extends across the entire design-to-construction lifecycle. Its software architecture promotes multi-disciplinary modeling and integrated clash detection powered by cloud computing. During construction, stakeholders can monitor project progress via mobile devices and upload site images, fostering dynamic interaction between field and office teams. Moreover, cloud platforms support data annotation and analytics, greatly enhancing communication efficiency and decision-making.

This model has gained widespread adoption in complex large-scale projects, construction sites, and remote collaboration scenarios. Additionally, many regional and industry organizations actively advocate for cloud-based BIM collaborative management systems, gradually establishing regional BIM data sharing and exchange networks [4-5].

2.1.3 Common data environment (CDE) construction

Built upon ISO 19650 standards, the Common Data Environment (CDE) constitutes a unified, standardized, controllable, traceable, and centralized project management system anchored in BIM. This system not only governs data processing workflows but also enforces user authentication and information exchange protocols. Its fundamental structure categorizes workflows into four stages: working, sharing, publishing, and archiving, each governed by clearly defined approval and transfer procedures.

In implementation, construction firms typically adopt the CDE model under the leadership of the project owner or supervisory entity, who serves as the sole authoritative source for project information. The CDE encompasses the creation and maintenance of product models, design drawings, and documentation, alongside the systematic management of modifications, construction records, inspections, and operational data extraction. This approach prioritizes data integrity and traceability, with meticulous recording of changes, approvals, and data dissemination.

In recent years, CDE has been increasingly embraced by major domestic projects. Internationally, some enterprises, referencing ISO 19650, have developed enterprise-level BIM collaboration frameworks that elevate BIM from mere tooling to comprehensive system management. Simultaneously, industry associations are committed to localizing CDE standards, thereby laying a solid foundation for future development and widespread adoption.

2.2 Status of Application by Stakeholders

2.2.1 Design phase

BIM technology has been increasingly embraced across engineering disciplines such as civil, structural, and electrical engineering. The fundamental structure and functional layout of a building require meticulous planning to construct its beams, slabs, and columns effectively. To address this, projects are adopting collaborative technologies such as work sharing and cloud computing to enable real-time information exchange among multiple domains, swiftly identifying and resolving inter-disciplinary conflicts, as well as efficiently sharing and rectifying errors and clashes inherent in existing algorithms [6].

Presently, BIM-based large-scale venues and major public buildings are gradually emerging as a novel architectural typology [7]. In China, construction firms predominantly employ centralized file collaboration and task decomposition models while leveraging cloud platforms for model access and user evaluation. During the design process, clash detection capabilities are fully utilized to preemptively correct mechanical piping and component collisions prior to documentation issuance, thereby minimizing subsequent revisions.

Moreover, the application of BIM extends beyond coordination, progressively encompassing performance analysis endeavors. Comprehensive assessments of buildings—including energy consumption analysis, daylight simulations, and evacuation modeling—are increasingly conducted. Certain projects have realized an end-to-end workflow facilitated by BIM technology, spanning from conceptual design through detailed construction drawings, even during the design phase, thus laying a continuous and comprehensive data foundation for subsequent construction and operational stages.

2.2.2 Construction phase

During construction, BIM data obtained in earlier phases underpins in-depth project planning and execution. This enables functionalities such as construction simulation, schedule management, quantity takeoff, and overall site management. Integration of BIM modeling with construction scheduling facilitates the development of 4D simulation systems that effectively monitor construction sequences, identify procedural conflicts, and apply corrective measures in practice [8]. Quantity takeoff processes employ BIM to extract vital material quantities—such as concrete, rebar, and piping—providing enterprises with robust bases for procurement planning and cost control. 5D-BIM has found extensive application in certain projects, linking components with cost data to realize component-based progress measurement and payment processing. On-site, personnel use mobile devices to access lightweight BIM models, conduct inspections, annotate issues, submit progress reports, and perform bidirectional updates between site conditions and model databases.

Throughout construction, project management personnel utilize BIM to establish a unified collaborative platform that enables modeling and information exchange among various professional subcontractors and labor teams. Subcontractors decompose the overall project per contractual obligations and relay progress updates back to the main schedule. Currently, BIM's role in construction project bidding and tendering processes is receiving widespread attention.

2.2.3 Operation and maintenance preparation

In the operation preparation stage, project teams are responsible for delivering comprehensive BIM models to the operation units. Increasingly, contracts incorporate BIM delivery requirements, mandating the handover of as-built model information accumulated during construction directly to the client. A critical aspect of this phase is ensuring that the BIM contains accurate, congruent data regarding equipment, spaces, and materials that can be seamlessly interfaced with operational and management systems [9-11].

In practice, contractors continuously build and maintain BIM models throughout project execution, incorporating equipment specifications, installation dates, supplier information, and maintenance manuals. Upon project completion, the data undergo rigorous review and transformation before being submitted to clients or facility management departments. Some projects integrate 3D modeling-based asset management by linking equipment records, spatial management, and maintenance workflows with BIM and operational management frameworks, achieving a sophisticated, model-driven facility management approach.

At present, complex facilities with stringent operational demands—such as airports, hospitals, and large shopping centers—are at the forefront of integrating BIM into early-stage operational research. These projects necessitate identifying relevant operation and maintenance entities early in construction and embedding BIM delivery standards and information classification frameworks. Several large enterprises have developed BIM-based enterprise operation and maintenance systems capable of capturing real-time information post-project completion and conducting daily operational and maintenance activities, thereby establishing a robust data transmission and management ecosystem.

3. Challenges in Collaborative Management of Architectural Engineering Projects Based on BIM Technology

3.1 Lack of Unified Standards

One of the foremost issues hindering BIM application is the absence of standardized protocols [12]. Disparate naming conventions and transmission standards among stakeholders, coupled with low modeling accuracy, necessitate extensive manual adjustments and data cleansing during model migration. Architectural firms segment tasks according to proprietary methodologies, impeding quantitative extraction and simulation of engineering data, thereby incurring substantial labor and resource expenditures for reconstruction and modifications.

At the industry level, although several BIM technical standards such as the Unified Standard for Building Information Model Application have been promulgated, most remain advisory rather than mandatory, resulting in suboptimal implementation outcomes. Various provinces and enterprises in China predominantly operate under their own standard systems, elevating collaboration costs across regions and organizations. Moreover, the differing specification requirements between design and construction phases signify a lack of cohesive standards.

In addition, data classification and coding systems are fraught with inconsistencies relating to component division, attribute definitions, and element measurement, exacerbating modeling complexities. Despite widespread BIM application, errors and omissions persist due to model specification and parameter selection issues, particularly within large-scale and complex projects where the multiplicity of endeavors and heterogeneous technical parameters sustain elevated collaborative costs. As shown in Table 1.

Table 1. Summary of Issues Pertaining to Lack of Unified Standards

Dimension	Manifestation
Naming and Modeling Norms	Divergent naming conventions, low modeling precision, inconsistent transmission protocols
Industry Standards	Predominantly advisory standards lacking enforceability, poor execution effectiveness
Regional and Enterprise Standards	Fragmented provincial and enterprise-specific standards, high cross-regional collaboration costs
Interdisciplinary Standard Variations	Designers emphasize geometry; constructors focus on processes and costs, lacking unified specifications
Data Classification and Coding	Inconsistent classification, attribute definition, and measurement elements, leading to heightened modeling difficulty

3.2 Ambiguity in Responsibility Boundaries

Collaborative BIM management entails coordination among owners, designers, contractors, supervisors, and consultants; however, the prevailing contractual frameworks and legal provisions lack explicit delineation of each party’s responsibilities [13-15]. Traditionally, project execution clearly segregated duties between design and construction entities. Yet, the BIM collaborative model necessitates joint creation and maintenance by multiple stakeholders, with identical components’ data often originating from diverse disciplines and undergoing numerous revisions, rendering it challenging to identify the origins of discrepancies.

Responsibility boundaries remain ambiguously defined, lacking precise scope specifications. As shown in Table 2. In the absence of rigorous version control and revision audit systems, any localized modification may inadvertently produce adverse repercussions across other departments. For instance, without prior communication with the property owner, the pipes were altered without authorization, which led to incorrect positioning of the bridge opening and consequently caused numerous engineering problems.

Furthermore, every phase of BIM demands precise determination of component dimensions and thicknesses, yet standardized accuracy criteria are still absent. In practical engineering, construction typically adheres strictly to the drawings' specifications. Nonetheless, issues arising during construction often prompt adaptive interventions, thus fostering insufficient consensus on the definitive quality benchmarks that must be achieved. Such a division of labor not only caused great difficulties for the cooperation, but also brought certain legal risks and disputes.

Table 2. Summary of Issues Associated with Ambiguity in Responsibility Boundaries

Dimension	Manifestation
Legal and Contractual	Contractual systems fail to explicitly define responsibilities of BIM collaborators
Model Collaboration Liability	Multi-party involvement in model maintenance complicates accountability tracing
Version Management	Lack of systematic version control and revision auditing leads to cascading issues from partial changes
Precision Standards	Absence of unified accuracy requirements for component dimensions and thickness
Legal Risks	Unclear responsibilities hamper collaboration and pose potential legal disputes

3.3 Delayed Data Transmission

Delayed data transmission is a pervasive issue within BIM collaborative workflows. As shown in Table 3. In reality, significant latency often occurs between successive nodes in the process. After modifications are made, it may take several days or even weeks before the finalized models reach construction firms. During this interim, contractors frequently continue to procure materials and organize sites based on outdated methods, thereby failing to meet evolving design requirements.

A principal cause lies in the reliance on manual coordination. Data editing, format adjustments, uploading, and publication after revisions necessitate skilled personnel, rendering the process both complex and protracted. Presently, many projects transmit model files via traditional means such as email or messaging platforms, lacking automated version comparison and change notifications. Consequently, recipients struggle to identify valid updates and must verify alterations independently, perpetuating a detrimental cycle.

Moreover, data transmission delays persist across different project phases. BIM originates in the initial design stage but undergoes frequent amendments throughout implementation without effective conversion mechanisms. Deep-level design outputs from construction entities often fail to communicate seamlessly with designers, leading to disjointed workflows epitomized by "design disregards construction; construction does not feedback design". During the operational commissioning phase, substantial discrepancies between as-built models and actual site conditions demand exhaustive verification and supplementation. Such delays severely undermine the BIM model's ability to realize its full lifecycle potential.

Table 3. Summary of Issues Related to Delayed Data Transmission

Dimension	
Time Lag	Model updates span days to weeks post-modification, hindering construction synchronization
Transmission Mode	Dependence on manual editing, conversion, and uploading; predominance of traditional tools such as email
Version Comparison	Absence of automated comparison and change alerts, necessitating manual validation
Phase Integration	Lack of effective data conversion mechanisms among design, construction, and operation stages
Model Validity	Significant deviations between as-built models and real conditions requiring substantial verification and supplementation

3.4 Poor Software Compatibility

BIM collaborative management has achieved widespread adoption across China; however, software compatibility remains a persistent challenge. As shown in Table 4. The predominant BIM applications employed domestically include Autodesk, Bentley, and Dassault systems. In practical usage, the Industry Foundation Classes (IFC) format frequently reveals significant performance disparities, often causing loss of geometric data, attribute inconsistencies, and difficulties in accurately identifying component types during data conversion [16].

Table 4. Summary of Problems Pertaining to Poor Software Compatibility

Dimension	Manifestation
Inter-Software Compatibility	Subpar IFC conversion performance among Autodesk, Bentley, Dassault, etc.
Data Conversion Quality	Loss of geometric data, attribute disorder, and difficulty in component recognition
Software Ecosystem Lock-in	Stakeholders confined to particular software, restricting flexible selection
Version Compatibility	Incompatibility among different versions of the same software requiring synchronized upgrades
Cloud Platform Disparities	Absence of standardized interfaces across diverse cloud platforms, impeding cross-platform collaboration

The lack of interoperability effectively binds stakeholders to specific “software ecosystems,” constraining their ability to tailor processes to unique business requirements. Construction enterprises typically rely on designated programs during execution, while architectural firms employ diverse software solutions for building simulation. This discrepancy necessitates additional data conversions and maintenance efforts in information exchange, resulting in substantial manual labor devoted to model transformation and correction. Such overhead not only escalates system costs but also introduces new errors.

Moreover, compatibility issues prevail even among different versions of the same software. Continuous software updates sometimes render generated models unreadable or unrenderable unless all collaborators synchronize their versions, thereby imposing significant operational expenses and managerial complexities. Although cloud computing technologies have shown promise in mitigating these compatibility challenges, the absence of a universal interface across disparate cloud platforms and the extensive heterogeneity of software employed by numerous participants severely limit BIM collaborative management’s widespread diffusion.

4. Causes Underlying the Challenges of BIM-Based Collaborative Management in Architectural Engineering Projects

4.1 Absence of Robust Institutional Mechanisms

A fundamental root of these issues lies in the inadequacy of institutional frameworks. At present, China has yet to establish a comprehensive BIM collaboration system encompassing the entire project lifecycle. Although certain BIM standards exist domestically, these predominantly serve as guidelines or recommendations, lacking mandatory enforceability [17]. Decisions regarding project scale, BIM utilization, and collaborative modalities are often determined by contracts or individual discretion, resulting in a deficient supervisory mechanism.

At the project management level, most initiatives lack an integrated BIM-based industrial collaboration platform. Manual processes and partial implementation persist in areas such as design approval, change control, and quality management, with BIM often relegated to an auxiliary role without functioning as a reliable source of authoritative information. For instance, when a company undertakes new developments, it frequently relies on modification orders or design drawings that must be recreated repeatedly, consuming substantial time and effort. Such system-level compartmentalization deprives BIM collaboration management of a solid foundation and procedural assurance.

Moreover, BIM technology faces unresolved challenges concerning responsibility delineation, intellectual property protection, and data confidentiality. Ambiguities in regulations governing data ownership, authorization, and modification liabilities engender numerous complications within data-sharing frameworks. Owing to the lack of systematic and stringent constraints, BIM collaboration is largely dependent on the voluntary initiative and enthusiasm of individuals, impeding the formation of a stable and sustainable cooperative model.

4.2 Insufficient Talent Skills

One of the main factors currently restricting the promotion of BIM is the shortage of talents. BIM collaborative management not only requires practitioners to have the ability to model, but also to deeply understand issues related to collaborative work processes, data management standards, and interface between different specialties. However, in current construction projects, there is a lack of high-quality BIM talents. Architects have certain design capabilities, but they are not familiar with construction processes and operation norms; project managers of construction projects have some understanding of construction projects, but lack the application and modeling of BIM.

At the level of talent cultivation, the current BIM teaching system in domestic universities and colleges of architecture engineering is not yet perfect, mostly focusing on "software", lacking systematic discussions on the "collaboration" concept and processes. During their studies, students lack practical experience, and after entering the enterprise, they also need to undergo certain adaptation and training. In terms of on-the-job training, most enterprises' BIM training mainly focuses on skills, lacking training on collaborative management, standard norms, and process systems, resulting in a common phenomenon of "able to use software, but not able to collaborate".

At the team level, their strength is also insufficient. BIM collaboration requires cross-professional and cross-position collaborative work, but currently there are very few professionals with BIM technology. Most employees are still limited to traditional working methods, resulting in a situation where "BIM teams work independently". This imbalance in personnel structure makes it difficult for BIM collaborative work to be integrated into the project work process, restricting the full exertion of its efficiency.

4.3 Difficulties in Aligning Stakeholder Interests

The diversity of BIM participants inevitably leads to significant conflicts of interest, which obstruct efficient collaborative use of information technology. Building owners seek to use BIM to reduce costs and improve quality but are unwilling to allocate additional funds; contractors invest substantial resources in BIM implementation but struggle to realize proportional financial returns. While BIM's widespread adoption brings considerable economic benefits to construction firms, it also generates enormous volumes of project data, disproportionately increasing workload and management challenges. This imbalance between input and reward discourages enthusiasm for collaborative engagement.

Effective BIM collaboration relies on transparent and continuous information sharing, yet in practice, contradictions abound. During construction, it is critical not only to ensure owners' access to updated project data but also to analyze and address practical challenges encountered on site. Without a clearly defined, equitable benefit-sharing mechanism, firms tend to adopt protective strategies to mitigate risks arising from data disclosure, resulting in guarded and limited cooperation. In some projects, BIM collaboration platforms exist merely in name, while data remains outdated, causing discrepancies from actual conditions.

At the contractual level, the deficiency of explicit BIM collaboration clauses leaves ambiguous the standards for model delivery, update frequency, responsibility allocation, and intellectual property rights. Despite universal aspirations to foster BIM advancement, legal disputes frequently arise due to inadequate contractual provisions. The absence of effective benefit coordination mechanisms deprives BIM participants of intrinsic motivation, thereby constraining practical application.

4.4 Limited Technological Investment

To a significant extent, constrained technological investment has become a bottleneck restricting the development of BIM technology. Collaborative BIM efforts necessitate continual funding in hardware, software licenses, cloud computing resources, and specialized expertise. However, amid declining construction industry profits, many firms and projects adopt a cautious stance toward BIM utilization—particularly small- and medium-sized enterprises deterred by steep costs associated with high-performance workstations, licensed software, and cloud platforms.

At the project level, owners typically omit dedicated BIM collaboration management budgets. Design and construction entities must divert funds from existing design fees or project payments, thereby limiting investment intensity. While some projects mandate BIM application, the absence of earmarked financial support compels implementers to adopt minimal-cost approaches, such as producing rudimentary models that fail to facilitate substantive collaborative management.

Funding restrictions also manifest in software selection and system integration. Budgetary constraints lead certain projects to cobble together low-cost environments using heterogeneous software, lacking professional configuration and maintenance of data interfaces, thereby precipitating frequent compatibility issues. Insufficient investment in servers, network bandwidth, and data backup further undermines the stability of both centralized file-sharing and cloud-based collaborative platforms. The paucity of technological investment leaves many projects trapped in a paradox of desiring BIM collaboration yet lacking the capacity to implement it effectively.

5. Strategies to Enhance Collaborative Management of Architectural Engineering Projects Based on BIM Technology

5.1 Standardization of Data Protocols

To address the prevailing lack of uniformity in BIM practices worldwide, it is imperative to expedite the formulation and enforcement of relevant standards. From a technical perspective, refinement of the IFC (Industry Foundation Classes) internal information exchange specifications is essential, alongside the development of interoperable platforms that seamlessly integrate diverse software ecosystems. Concurrently, national standards such as the Building Information Model Storage Standard and the Building Information Model Classification and Coding Standard must be optimized to align with the practical demands of China's construction industry, thereby strengthening their operability and mandatory compliance.

At the enterprise level, large-scale design institutes, contractors, and consulting firms should establish rigorous corporate BIM standards systems that explicitly stipulate model naming conventions, component classifications, and modeling accuracies, enforcing strict adherence. For inter-organizational collaborations, project owners or general contractors must spearhead the formulation of unified project-level BIM implementation plans prior to commencement, clearly defining standard requirements and embedding them within contractual fulfillments, thus eradicating fragmented, isolated approaches.

Technologically, BIM standard verification tools should be developed to enable automated conformity checks of models, reducing reliance on costly manual audits. Coupling this, a comprehensive BIM standards database and knowledge repository ought to be constructed to provide accessible reference materials, case studies, and query services, integrating standard compliance into routine modeling workflows and lowering execution barriers. The concerted multi-party promotion of unified data standards forms the cornerstone for effective BIM collaborative management.

5.2 Define Responsibility Division

It is necessary to establish separate models for rights and responsibilities configuration in terms of contract agreements, contract processes, and contract structure hierarchy. At the contract level, through the application of BIM in specific projects or the signing of dedicated BIM contracts, the scope of BIM work, results, quality standards, update frequency, intellectual property ownership, and legal effect can be clearly defined; the contract stipulates that the design unit is responsible for the accuracy and completeness of the product, and requires the client to make corrections and conduct timely checks.

At the process design level, clear production release and change authorization processes need to be formulated. Model adjustments require approval from relevant departments; after model updates, a clear release mechanism needs to be established to ensure that all personnel use the unified release version; the requirements for each precision level and the interrelationships between levels need to be clearly defined. After design changes, the BIM model needs to be updated promptly and used as the authoritative change method.

At the organizational structure level, a BIM supervisor or BIM coordinator should be established to ensure the orderly operation of BIM; for major projects, a BIM technical expert group can be formed, with joint discussions by all departments to address issues. The owner, as the ultimate person responsible for the project, should actively assume the responsibility of organizing and coordinating BIM collaboration, monitor and evaluate related work, clarify the division of responsibilities for each function, and formulate collaborative procedures to avoid shirking.

5.3 Optimization of Platform Integration

In the networked environment, urgently resolving the seamless interconnection of functional modules and the construction of unobstructed data transmission channels is paramount. Platform selection strategies must actively circumvent overdependence on proprietary, single-vendor solutions, favoring the development of open, interoperable BIM application platforms. Cloud-based collaborative platforms, for instance, can offer open interfaces accommodating diverse user roles and supporting modular workflows, thereby substantially alleviating software compatibility constraints.

Standardized data exchange protocols should be established across software suites, explicitly prescribing communication procedures for each process stage, materials handling, conversion methodologies, and quality assurance criteria. Introduction of specialized document conversion and verification services will empower experts to execute smooth input-output operations between heterogeneous software, safeguarding data integrity and completeness. Amidst voluminous data exchanges, automation and embedded processing are indispensable for reducing human intervention, thereby enhancing interaction effectiveness and trustworthiness.

Building on this foundation, a data transmission timeliness assurance framework must be instituted, balancing immediacy with accuracy. Production changes should be executed promptly within specified deadlines, compelling contractors to complete final acceptance inspections swiftly following receipt of updated models. Cloud computing systems require real-time information functionalities, proactively pushing updates to relevant personnel while clearly pinpointing modification locations and contents, significantly alleviating manual verification workloads. Simultaneously, system optimization efforts should resolve multi-system compatibility challenges, minimizing subsystem handoffs and elevating the responsiveness of integrated collaborative platforms.

5.4 Strengthening Talent Development

To substantially alleviate the acute shortage of BIM professionals in vocational colleges and higher education institutions, it is imperative to establish a comprehensive, multi-tiered, and systematic talent cultivation framework. Within academic institutions, BIM collaborative management must be embedded as a cornerstone course, encompassing curricula such as BIM principles, collaborative workflows, data standardization protocols, and Common Data Environment (CDE) management, fostering students' capacity for systemic thinking and coordinated project oversight. In parallel, academia and industry should collaboratively establish BIM training bases, promoting immersive project engagement for students and smoothing their transition into professional roles.

At the enterprise level, training programs should be tailored to occupational roles: information engineers focus on software proficiency and modeling standards; project personnel concentrate on collaboration processes, standard application, and team coordination; senior management immerses in strategic modeling, investment returns, and risk mitigation. A blended approach of online instruction, intensive face-to-face sessions, and practical fieldwork should be implemented, aligning BIM competency development with professional advancement pathways to cultivate continuous learning culture.

Industry-wide, trade associations must assume a leading role in orchestrating BIM training and certification initiatives and establishing professional knowledge-sharing platforms to facilitate high-level information exchange. Implementing mentorship-based, hands-on teaching models will enrich the skill sets of practitioners, ensuring alignment with evolving industry demands. Through systematic and sustained capacity building, the industry can secure a robust pipeline of proficient BIM professionals, underpinning enterprise and academia collaborative governance and operational excellence.

6. Conclusions

Building upon a systematic review of BIM technology applications, this study critically examined the prevailing challenges in construction project management—namely, the lack of unified standards, ambiguous delineation of responsibilities, delayed data transmission, and poor software interoperability. These issues were further analyzed through the prism of underlying factors such as institutional deficits, inadequate talent capacity, difficulties in aligning stakeholder interests, and insufficient technological investment. In response, four targeted countermeasures were proposed: standardization of data protocols, clarification of duty allocations, optimization of platform integration, and enhancement of talent development—thus constructing a comprehensive research trajectory from problem identification and cause analysis to strategic remediation.

With the progressive integration of emerging technologies such as digital twins, artificial intelligence, and the Internet of Things into BIM, the trajectory of construction engineering inexorably trends towards increased intelligence and automation. Against this backdrop, engineering collaboration models centered around cloud platforms and Common Data Environments (CDE) are poised to gradually crystallize, concurrently fostering the cultivation of a highly skilled BIM workforce. Accordingly, it is imperative that relevant authorities expedite the promulgation of legislations and policies, while enterprises amplify investment in research, development, and training. These concerted efforts will elevate construction management from mere functionality to optimal usability, thereby ensuring seamless information flow and effective collaboration throughout the construction lifecycle.

References

[1] Long Yu. Practice of Collaborative Management for Construction Projects Based on BIM Technology. Urban Development, 2025, (21): 132-134.
[2] Liu Lihong. Research on Construction Schedule Control Based on BIM Technology. Housing and Real Estate, 2025, (29): 68-70.
[3] Lou Yino. Exploration of the Application of BIM Technology in Integrated Management of Residential Construction Projects. Housing and Living, 2024, (32): 155-158.
[4] Gao Yunpeng. Research on the Application Management and Practice of Residential Building Materials Based on BIM Technology. Housing and Living, 2024, (25): 143-145.
[5] Wang Yong. Practice of Construction Collaborative Management in Steel Structure Projects Based on BIM Technology. Building Science, 2024, 8(01): 12-14.
[6] Zhang Nan. Design of Full Life Cycle Health Management for Construction Projects Based on BIM Technology. Brick and Tile, 2023, (08): 112-114.
[7] Li Xiao, Guo Juan, Chen Shilin. Research on Progress Management Methods in Construction Projects from the Perspective of Collaborative Construction. Mass Standardization, 2023, (11): 88-90.
[8] Wang Shanshan. Research on the Application of BIM Technology in Construction Projects. Bulk Cement, 2023, (01): 102-104.
[9] Ding Jie, Zheng Nan, Sun Shicheng, et al. Research on Information Collaborative System for Construction Projects Based on BIM Technology. Sichuan Building Materials, 2023, 49(01): 233-234.
[10]Zheng Yi. Discussion on Construction Project Progress Management Based on Collaborative Construction. Jiangxi Building Materials, 2021, (10): 376-377.
[11]Teng Bo. Application Value of BIM Technology in Construction Projects. Sichuan Cement, 2021, (08): 71-72.
[12] Ye Junhua. Application of BIM Technology in Construction Projects. Residential Industry, 2021, (Z1): 56-58.
[13] Xu Yingbiao. Application Value and Practice of BIM Technology in Modern Construction Project Management. Engineering Technology Research, 2021, 6(01): 128-129.
[14] Yan Pei. Research on the Collaborative Development Path of Construction Project Management and Construction Technology. Journal of World Architecture, 2025, 9(6):148-156.
[15]Xue Yutong, Le Yun, Jiang Kaiwen, Gan Xueqing. Collaborative Management Framework for Interorganizational Risk in Megaprojects Based on Metanetwork. Journal of Management in Engineering, 2024, 40(5).
[16]Xiaoyan Chen, Ting Wang, Yan Liu, Zixin Dou. Configurational Path to Collaborative Innovation in Large and Complex Construction Projects.Buildings, 2024, 14(1).
[17]Chenwen Zhan, Chunwei Fu, Xiaohong Wu. Research on collaborative construction management of construction project based on BIM technology. International Journal of Critical Infrastructures, 2023, 19(1):79-93.