World Scientific Research Journal Volume 11 Issue 7, 2025
ISSN: 2472-3703 DOI: 10.6911/WSRJ.202507_11(7).0002

Construction and Application of a Refined Management Smart Information Repository Based on BIM Technology

Shu Tang, Yujie Yang, Zhilin Zhang

Southwest Petroleum University, Sichuan, Nanchong, 637000, China

Abstract

Data from the China Construction Industry Association in 2023 shows that over 60% of large construction enterprises nationwide have deployed smart construction site systems. However, the industry faces challenges such as high-cost constraints and uneven regional development. This paper constructs a smart information repository comprising six sub-repositories: BIM, Personnel, Materials, Quality, Equipment, and Environment. It achieves digital management throughout the entire construction lifecycle through technological integration. Case validation demonstrates that this system can reduce construction costs by 18%-25%, shorten construction periods by 13%, and provides an innovative pathway for the development of smart construction sites.

Keywords

Smart Construction Site; Refined Management; Material Recycling; BIM Application.

1. CONSTRUCTION OF THE SMART INFORMATION REPOSITORY

With strong support from national policies, the introduction of BIM technology into smart construction sites in China has yielded positive results in several implementation cases. For instance, in a large complex project located in the Beijing Economic-Technological Development Area, BIM technology serves as the cornerstone of smart construction site development, running through the entire project lifecycle.[1] Research and application in the field of smart construction sites and intelligent construction started earlier abroad and have achieved significant results. Under the coordination of BIM technology, smart construction sites have developed well. However, issues such as diverse sources of construction data, lack of unified data processing standards, information silos, and insufficient BIM compatibility hinder development in most cases..[2] Analysis shows that many smart construction sites face problems like high-cost constraints and uneven development.

To address these issues, we constructed a smart information repository based on BIM technology. The logical relationships are shown in Figure 1:

2. APPLICATION OF THE SMART INFORMATION REPOSITORY

2.1. BIM Application

Responding proactively to policy calls, the smart information repository utilizes BIM technology to create 5D models for refined management. Through the integration of BIM technology, the information repository, and external tools, dynamic data is collected to build dynamic construction simulation models. These models map the physical engineering state in real-time, providing a visual basis for deviation analysis and early warning. Simultaneously, through modular functional design, repository data is transformed into management decision support tools. Progress management for the entire construction process involves regularly

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202507_11(7).0002

comparing planned versus actual progress deviations. Differences are quantified using color annotations on 3D models and data tables, enabling visual risk localization.

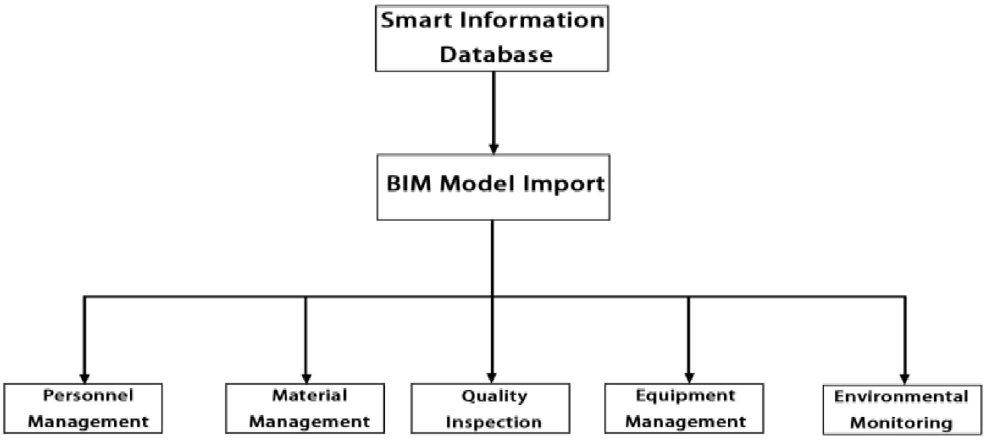

Figure 1. Smart Information Repository Based on BIM Technology

2.2. Personnel Management Sub-Repository

2.2.1 Dynamic Personnel Planning and Intelligent Allocation

Based on 3D progress simulations from the BIM model, the system automatically generates dynamic personnel demand matrices, precisely quantifying the required workforce configuration for each phase:

(1) Capacity Matching: Automatically calculates peak demand for steel structure installers during the main structural phase, predicting labor fluctuation curves using historical project data.

(2) Role Profiling: Constructs a 12-dimensional job competency model for intelligent matching of key positions and dynamic verification of qualifications for special operations personnel.

(3) Permission Adaptation: Develops a three-tier dynamic permission system, allowing project managers to adjust BIM model operation permissions for site engineers in real-time.

2.2.2 Task Collaboration and Smart Communication

Establishes a dual-driven "task-communication" mechanism to achieve precise linkage between "Person-Position-Task," as shown in Table 1:

Table 1. Task-Person-Position Linkage Mechanism based on BIM Technology

Task Type	Allocation Logic	Communication Mechanism
Routine Tasks	BIM model decomposition → job matching degree ranking	Automatically create enterprise WeChat task groups
Emergency Tasks	GPS positioning of the nearest idle personnel	Strong reminder + direct video conference connection
Cross Tasks	Multi-professional collision detection → collaborative group construction	AR remote marking collaboration)

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202507_11(7).0002

2.2.3 Full Lifecycle Capability Development System

Constructs a "Training-Practice-Assessment" closed loop to enable continuous role upgrading, as detailed in Figure 2:

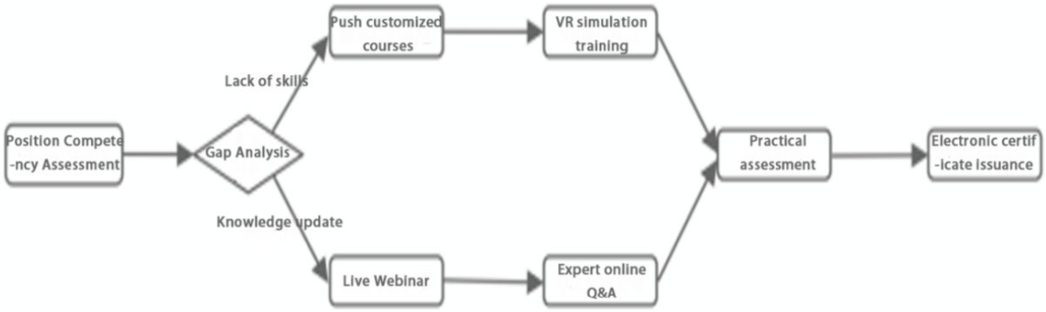

Figure 2. "Training-Practice-assessment" Closed-loop Diagram

2.3. Dynamic Material Management Information Sub-Repository

This system constructs a dynamic material management system based on BIM and IoT technologies, achieving digital control throughout the material lifecycle. It employs an intelligent inventory model where material storage quantities dynamically adjust based on project progress, and material types are intelligently matched to construction needs, forming an adaptive smart management hub.

2.3.1 Inventory Management

Automatically generates dynamic material demand curves based on the BIM progress model, establishing an inventory threshold adjustment mechanism integrated with the construction schedule. All incoming materials must be recorded via mobile terminals, including production batch numbers, quality certificates, manufacturer information, and expiration dates. The system automatically generates timestamped electronic records.[3] Smart weighing scales and RFID scanning gates deployed in storage areas work together to collect real-time material arrival data. The system automatically triggers alerts when actual inventory deviates from dynamic model predictions. Early warnings are pushed for materials nearing expiration. Managers can also view complete traceability information for any batch of materials through the system.

2.3.2 Quality Monitoring

Building upon traditional environmental monitoring, a material lifecycle tracking module is innovatively introduced. Each material unit is equipped with an encrypted QR code label. Combined with multi-dimensional sensor data (temperature, humidity, vibration, light exposure), a material quality degradation model is built, automatically suggesting adjustments to construction plans.

2.3.3 Intelligent Recycling

The system innovatively applies a Material Regeneration Potential Index (MRPI) assessment system. This index comprises structural performance retention rate, chemical stability coefficient, and recycling economics. Laser 3D scanning captures deformation data of discarded steel, while electrochemical testing measures corrosion current density. The system automatically calculates the MRPI value. Materials with MRPI ≥ 60 are recommended for direct reuse; scores between 30-59 enter the recycling process; scores <30 initiate environmentally

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202507_11(7).0002

sound disposal. Blockchain technology is introduced to establish a "digital passport" for materials, recording full lifecycle data from production and use to recycling.

2.4. Full Lifecycle Quality Inspection Sub-Repository

2.4.1 Critical Node Inspection Mechanism

(1) Mandatory Inspection Nodes: Includes 12 critical processes such as the ±0.00 elevation level and transfer slab pouring. Uses 3D laser scanning for automatic comparison with the BIM model to control dimensional deviations.

(2) Periodic Inspection Nodes: Conducts weekly intelligent inspections on concrete strength and steel structure welds.

2.4.2 Intelligent Concealed Works Management

Concealed works must undergo strict quality inspection before being covered. The smart information repository is used to meticulously record designated inspection points for concealed works, including location, construction content, and inspection data. During inspection, quality managers comprehensively assess construction quality by querying data in the repository. Inspection results are recorded in the repository, forming a vital part of the project's quality records and providing a basis for future maintenance and renovation.[4]

2.5. Equipment Management Sub-Repository

2.5.1 Pre-construction Equipment Information Integration

Constructs an equipment tree structure via BIM, solving traditional identification chaos issues and improving equipment retrieval speed by 80%, enabling refined management. Integrates procurement and warehousing data. During the construction phase, records planned vs. actual delivery deviations. During operation, tracks spare parts inventory movements, ensuring ledger accuracy. Data is coherently recorded from planning to decommissioning. Construction phase supervision reports are automatically linked to operation phase maintenance work orders, eliminating duplicate data entry.

2.5.2 Equipment Preservation and Maintenance During Construction

The BIM 3D model precisely locates equipment faults, improving maintenance efficiency by 50%. Historical data analysis predicts potential failures; preventive maintenance reduces unplanned downtime by 40%. The system automatically generates maintenance plans, matches spare parts inventory, achieving a maintenance response time of <2 hours; enables multi-department data sharing.

2.5.3 Equipment Selection and Efficiency Improvement During Construction

Integrates equipment technical parameters and maintenance cost models. Compares performance degradation curves of different equipment and recommends optimal solutions based on project requirements, reducing selection deviation rate to <5%. Sensors collect real-time vibration and temperature data; machine learning predicts component lifespan; 3D models shorten fault diagnosis cycles by 30%. Dynamic equipment allocation reduces idle rates by 25%.

2.6. Construction Environment Monitoring Sub-Repository

The construction environment monitoring sub-repository establishes a multi-dimensional environmental sensing system through the BIM cloud platform and a sensor network.[5] For air quality monitoring, deployed laser scattering particulate sensors collect 13 indicators (PM2.5, PM10, TVOC, etc.) in real-time. Combined with wind speed and direction data from weather stations, a dust dispersion model is built. The system automatically triggers high-pressure mist cannon systems when PM10 concentrations exceed thresholds. Noise monitoring uses array microphones with sound source localization, creating an acoustic electronic fence at the

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202507_11(7).0002

construction site boundary. The water quality monitoring system integrates multi-parameter water quality analyzers for online detection of 9 parameters at site drainage outlets. It automatically closes drainage valves and activates neutralization units upon detecting abnormal pH levels.

After wireless transmission to the BIM cloud-based smart information repository, the system automatically generates 3D visualizations of the construction environment and various monitoring indicators. Managers can view the environmental status of each monitoring point in real-time via mobile devices.

3. SPECIFIC CASE ANALYSIS

3.1. Project Background

A green residential project was selected as a case study. Total construction area: 120,000 square meters. Includes 4 prefabricated high-rise residential buildings and supporting commercial facilities. The project aims to achieve China's 2-Star Green Building Standard. Construction period: 28 months.

3.2. Integrated Application of the Smart Information Repository

BIM Application: Integrated multi-disciplinary models detected 127 instances of pipeline clashes, reducing rework costs by approximately 600,000 yuan. 5D progress comparisons generated daily deviation reports, reducing schedule delay rates from 18% to ≤5%, shortening the construction period by about 4 months.

Materials: RFID tags tracked steel throughout its lifecycle; automatic allocation of backup resources occurred during transport delays. Concrete inventory thresholds triggered automatic replenishment, reducing backlog by 25% and saving 450,000 yuan in warehousing costs. Steel waste rate dropped to 3% (saving 2 million yuan).

Quality: Workers scanned construction areas using AR glasses. The smart information repository overlaid the BIM model onto the real scene in real-time, automatically highlighting areas with insufficient overlap width or voids. Inspection efficiency increased by 60%, missed inspection rates dropped from 15% to 3%, while also preventing large-scale rework. Key results are shown in Table 2.

Table 2. Comparison of Application Effectiveness

Indicator	Traditional Management Mode	Smart Information Database Application	Improvement Effect
Construction Progress	Average Delay Rate 18%	Delay Rate ≤5%	Construction Period Shortened by 13%
Material Waste	Steel Waste Rate 8%	Waste Rate Reduced to 3%	Cost Saved 2 Million Yuan
Quality Rectification	Manual Inspection Takes 3-5 Days	AI Early Warning Instant Push	Response Time Shortened to 4 Hours
Safety Accidents	1.2 Times/Million Working Hours Annually	0.4 Times/Million Working Hours	Risk Reduced by 67%

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202507_11(7).0002

4. PROSPECTS AND CONCLUSION

4.1. Application Prospects

BIM technology, as a core tool, enables full lifecycle management from design to operation and maintenance in large projects. Furthermore, the promotion of 5G networks and edge computing provides hardware support for real-time data transmission and localized processing. Policy subsidies further reduce the burden on enterprises. The national "14th Five-Year Plan" for Intelligent Construction explicitly supports smart construction site development; the "Guide for Smart Construction Site Development" provides a standardized framework. Local governments promote transformation through green construction evaluations. Therefore, the application prospects for the smart information repository are broad.

4.2. Conclusion

This paper systematically expounds on the value and implementation path of the smart information repository from three dimensions: technological application, case practice, and feasibility analysis. As a core vehicle for the digital transformation of the construction industry, the smart information repository, through the deep integration of cutting-edge technologies such as BIM, IoT, and AI, provides a comprehensive, multi-dimensional solution for construction management.

ACKNOWLEDGEMENTS

Nanchong City School Science and Technology Cooperation Project: “Research on Fine Management of Construction Projects in Nanchong City Based on BIM Technology” (18SXHZ0061)

REFERENCES

[1] Qiu Jiang, Zhao Xuyang, Li Haipeng, et al. Summary and Reflection on the Implementation of Smart Construction Site Systems [J]. Intelligent Building and Smart City, 2025, (03): 19-21. DOI:10.13655/j.cnki.ibci.2025.03.005.

[2] Chen Minqiang. Problems Faced by Construction Companies in Promoting the Application of Smart Construction Sites [J]. Low Carbon World, 2024, 14(03): 172-174. DOI:10.16844/j.cnki.cn10-1007/tk.2024.03.025.

[3] Zhao Yi. Analysis of the Application of Refined Management in Residential Building Construction [J]. Theoretical Research in Urban Construction (Electronic Edition), 2024, (30): 82-84. DOI:10.19569/j.cnki.cn119313/tu.202430028.

[4] Liu Shouyu, Song Haigang, Zhou Liang, et al. Architecture of a Refined Collaborative Management Platform Based on BIM+ Smart Construction Site [J]. Chongqing Architecture, 2022, 21(03): 23-25.

[5] Gansu Third Construction Group Co., Ltd. A Dust Monitoring System for Construction Environment: CN202510169003.6 [P]. 2025-03-18.