Application of BIM Technology in Engineering Project Management at Beijing Tiantan Hospital (Postprint)

Authors: Gao Mingjie; He Qing

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Abstract

The Tiantan Hospital project, undertaken by China Construction First Group Corporation as the general contractor, is currently the largest hospital project under construction in Beijing. From the project' s inception, emphasis was placed on developing the application of BIM technology in the project. In addition to providing fundamental construction technical guidance, BIM technology was further applied to project management, thereby laying the foundation for the smooth progress of the Tiantan Hospital project. This paper focuses on introducing the application of BIM technology in this project.

Full Text

Preamble

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Application of BIM Technology in the Management of Beijing Tian Tan Hospital Project

Gao Mingjie, He Qing
(China Construction First Building (Group) Co., Ltd., Beijing 100161)

Abstract: The Tian Tan Hospital project, undertaken by China Construction First Building (Group) Co., Ltd. as the general contractor, is currently the largest hospital under construction in Beijing in terms of building volume. From the outset, the project has prioritized the application of BIM technology, extending its use beyond basic construction technical guidance to project management, thereby laying a solid foundation for the smooth execution of the Tian

Tan Hospital project. This paper focuses on introducing the application of BIM technology in this project.

Keywords: BIM System Software and Hardware Configuration and Organizational Planning; BIM Technology; Project Management; Application

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1. Project Overview

The Beijing Tian Tan Hospital relocation project is located at the northeast corner of Huaxiang Bridge in Fengtai District, Beijing, with a total construction area of 267,931 m^2 and a site area of 272.6 acres. The main structural forms include concrete frame-shear wall and steel structure (outpatient building), with three underground floors and five to eleven above-ground floors. The project comprises 11 individual buildings integrating outpatient, emergency, inpatient, and research functions. The total construction period is 915 days, with a start date of May 1, 2014, and a planned completion date of October 30, 2016. The exterior design features a unique neuron-inspired 图腾 concept for the specialized outpatient building, creating a spacious, transparent, and aesthetically pleasing main entrance hall [Figure 1: see original paper].

[Figure 1: see original paper] Beijing Tian Tan Hospital rendering

Given the project' s large scale, complex structural forms, numerous medical electromechanical and equipment systems, and frequent interdisciplinary coordination, it presents significant challenges in construction organization, resource allocation, and general contractor coordination. To address these challenges, the project established a BIM team of over 20 personnel to conduct BIM organizational planning, aiming to leverage BIM technology for both construction guidance and project management.

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2. BIM System Software/Hardware Configuration and Organizational Planning

2.1 Deployment of Software and Hardware

After evaluating various BIM software and hardware options, the Tian Tan Hospital project department ultimately selected Autodesk' s Revit and Navisworks software, Trimble' s Tekla software, and Glodon' s GCL, GGJ, BIM drawing review, BIM browser, and BIM solution systems. For hardware, the project department set up a server as the database terminal, equipped with

high-performance computers (i7 processor, 32 GB RAM, 2 TB hard drive) and 100 Mbps dedicated fiber optic infrastructure, ensuring smooth operation of the project BIM system.

2.2 Formation of BIM Team

China Construction First Building (Group) attaches great importance to BIM talent development. During the early project phase, technical personnel underwent multiple BIM training sessions. Through combined theoretical and practical cultivation, the Tian Tan Hospital project department established a young and dynamic BIM team with dedicated full-time BIM specialists who gradually evolved from novices into an elite team [Figure 2: see original paper].

[Figure 2: see original paper] Tian Tan Hospital BIM organizational structure chart

2.3 Development of Unified BIM Standards

Before commencing BIM work, project personnel collaborated with Glodon' s consulting team to develop the *BIM Implementation Guidelines*, *BIM System Technical Standards*, and *BIM Work Standards* (including *Overall Implementation Plan*, *Specialized Application Standards*, *Work Specifications*, *Model Building Standards*, and *Delivery and Acceptance Standards*), providing favorable guarantees for the smooth implementation of subsequent BIM work.

2.4 Establishment of Project Templates and Family Libraries

Before formal modeling, each discipline established corresponding template files [Figure 3: see original paper], and created over 500 professional family files for civil engineering, electromechanical, medical, and other specialties according to project requirements and family library management rules, forming valuable reusable assets for similar future projects.

[Figure 3: see original paper] Sample file illustrations

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3. BIM Application in Construction Technology

3.1 Collision Detection and Pipeline Optimization

Adhering to the concept of modeling while applying, the Tian Tan Hospital project synchronized deep design work with model updates. Collision detection identified at least 360 major collisions in the basement, 210 in the main building, and 58 drawing issues. Subsequent pipeline optimization considered not only the model itself but also on-site installation sequences, maintenance spaces, and support/hanger installation, achieving zero collisions after adjustment [Figure 4: see original paper]. This work directly reduced numerous rework instances for the project department, saving over one million yuan in costs.

[Figure 4: see original paper] Tian Tan Hospital BIM civil and electromechanical models

3.2 Visualization Briefing and On-site Verification

The Tian Tan Hospital project department held weekly deep design meetings for various disciplines. The three-dimensional, intuitive, and stereoscopic models effectively facilitated communication on detailed positions, saving approximately 10% of communication time. The project combined BIM models with on-site installation conditions to conduct comparative verification of key locations, ensuring construction teams executed work according to drawings with guaranteed quality and quantity [Figure 5: see original paper].

[Figure 5: see original paper] Electromechanical integrated model vs. on-site physical implementation

3.3 3D Site Layout

With 10 building structures under simultaneous construction, rational layout of the dynamic construction site presented a major challenge. BIM technicians virtually constructed all on-site objects, optimizing layout plans through walkthroughs and simulated installation/dismantling sequences to ensure smooth transportation routes and convenient construction personnel management, effectively avoiding secondary handling and accidents [Figure 6: see original paper].

[Figure 6: see original paper] 3D site model

3.4 Electromechanical System Verification

Building upon conventional BIM applications, the Tian Tan Hospital project conducted deeper-level applications such as electromechanical system verification. Detailed verification was performed on air and water systems in the basement, model rooms, and equipment rooms within the BIM model, calculating system pressures, pressure drop values, and valve openings to provide accurate guidance for on-site commissioning personnel and establish fundamental data for future operation and maintenance warnings and maintenance [Figure 7: see original paper].

[Figure 7: see original paper] System verification analysis

3.5 Formwork Safety Verification and Prefabricated Component Processing

With 11 buildings in the project, the measure items involved substantial 工程量. The project department utilized Glodon' s formwork products for safety verification of external scaffolding, ensuring safe construction. The calculated formwork quantities also provided valuable guidance for subsequent material

procurement. Effective application of prefabricated component processing technology significantly contributed to project schedule assurance and advancement. The project department broke down and quantified water pipes, air ducts, and cable trays according to modular requirements, enabling factory prefabrication.

3.6 Precise Brick Layout

The project department used Glodon software's one-click brick layout function in the BIM model' s secondary structures. By simply selecting the wall surface and inputting corresponding parameters, one-click brick layout was achieved, with layout drawings outputted to guide construction, improving work efficiency by over five times [Figure 8: see original paper].

[Figure 8: see original paper] Brick layout implementation

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4. BIM Application in Project Management

4.1 Model and Construction Data Integration

Project personnel utilized the BIM platform to load models created with Revit, Tekla, GGJ, and other BIM tools, as well as data from Project, Word, Excel, and other office software, linking schedule, drawing, quality/safety, and cost business data to the models. This formed the Tian Tan Hospital project' s BIM data center and collaborative application platform, ensuring multi-department and multi-position coordinated application and providing support for refined project management.

4.2 BIM-Based Schedule Management

Addressing schedule management challenges, project personnel imported and linked plans with models. Based on site conditions, the system displayed 3D dynamic schedule simulations, enabling retrieval of 工程量 within any time point or period to effectively guide owner quantity reporting and subcontractor verification. Ten quantity reports have been completed to date, with schedule data basically meeting owner requirements. The BIM management system set 13 milestone events and over 20 warning messages, identifying four instances of unmet milestone nodes and triggering five types of warning messages that were simultaneously sent to relevant personnel, helping management optimize schedules and plans to ensure 工期.

Concurrently, the BIM management system assigned supporting works linked to the schedule plan to corresponding departments based on their responsibilities, which were then assigned by department heads to specific implementers, achieving accountability to individuals and creating an executable schedule plan [Figure 9: see original paper].

[Figure 9: see original paper] BIM 5D schedule management

4.3 BIM-Based Drawing Management

The Tian Tan Hospital project linked drawings with corresponding models, enabling quick query of detailed professional drawing information for specified components, including different drawing versions, drawing modification sheets, design change negotiation documents, and Q&A files. For 1,204 drawing changes, the drawing module dynamically tracked corresponding application statuses. Using the advanced drawing search function, relevant drawings and information could be quickly located among massive drawing sets—a task previously requiring 2-3 people and one hour can now be completed within minutes by inputting conditions in the advanced search, improving speed by several times compared to traditional methods [Figure 10: see original paper].

[Figure 10: see original paper] BIM 5D drawing management

4.4 BIM-Based Commercial Management

The Tian Tan Hospital BIM model enabled automatic 工程量 calculation and multi-dimensional 工程量 summarization. The project department linked BIM models with general and subcontract contract unit price information, enabling query of 工程量 and corresponding contract unit price and total price information for specific components. For general contractors, effective integration of BIM and commercial management represents the most important aspect of BIM technology value. Particularly with rapid development of one-click BIM quantity calculation and BIM-based general/subcontract management models, BIM application in commercial management has been further promoted.

To verify model usability, the project adopted a progressive checking approach: first local areas, then single-floor horizontal components, followed by multi-floor vertical components, with identified issues corrected promptly. To verify 工程量 accuracy, the project compared Revit models with commercial GCL models, finding precision errors of less than 1%, confirming model correctness.

For owner quantity reporting and subcontractor verification, the project department selected model scopes based on schedule plans, automatically calculating 工程量和 reporting amounts to facilitate owner quantity applications and subcontractor quantity approvals, improving efficiency by over two times compared to previous methods.

For cost management, the project department utilized the BIM management system for automatic cost accounting, achieving three-way comparison of budget, income, and expenses. Management could view cost comparison analysis and cost trend analysis through line charts, enabling timely decision adjustments and control direction to achieve intuitive, real-time, and refined cost management [Figure 11: see original paper].

[Figure 11: see original paper] BIM 5D commercial management

4.5 BIM-Based Quality and Safety Management

The project department recorded 28 quality issues and 200 safety issues through mobile on-site collection or PC input, with effective supervision through assigned adjustment personnel and timelines. Data accumulation and analysis identified frequent quality and safety problem locations, helping management prevent issues in advance and deploy focused inspection priorities to optimize resources [Figure 12: see original paper].

[Figure 12: see original paper] BIM 5D quality and safety management

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5. BIM Application in Project Operation and Maintenance Phase

5.1 Integration of BIM and IoT for Operation and Maintenance Management

BIM models contain fundamental data and information on component locations, dimensions, installation times, and manufacturers for hidden works, electromechanical pipelines, and valve groups, facilitating operation and maintenance management during project delivery and use. This improves work efficiency and accuracy while reducing time, material waste, and failure losses when faults or situations occur.

(1) **Remote Equipment Control:** Various independently operating devices can be aggregated onto a unified platform for management and control through RFID and other technologies, enabling both equipment status monitoring and remote control.

(2) **Visualization of Internal Space and Facilities:** BIM establishes a visual 3D model from which all data and information can be retrieved.

(3) **Spatial Positioning of Systems and Equipment:** Location information for lighting, fire protection, and other systems and equipment transforms traditional numbering or text representation into 3D graphical positions for easier location and intuitive visualization.

(4) **Operation and Maintenance Data Accumulation and Analysis:** Accumulation of various project operation and maintenance data holds significant management value. Data analysis can identify existing problems and hidden dangers, as well as optimize and improve current management. For example, RFID can obtain meter readings to form energy consumption patterns over time, while accumulated data can analyze vacant parking space conditions during different periods for garage management.

5.2 Cloud-Based BIM Management

During the BIM specialized application phase, the project established a BIM information sharing platform through Glodon Cloud, serving as a platform for BIM team data management, task distribution, and information sharing.

(1) **Unrestricted Information Access:** Cloud sharing enables information access from anywhere with network connectivity.

(2) **Enhanced Cross-Disciplinary Collaboration:** Models stored in the cloud can be accessed through any network connection.

(3) **Significant Cost Savings:** Transitioning to cloud computing can save up to 67% of server lifecycle costs.

(4) **Easy Implementation and Maintenance:** Cloud computing mode requires virtually zero implementation and maintenance workload.

Conclusions

(1) BIM application requires investment of human, material, and financial resources and must receive leadership attention and support.

(2) BIM application is not the independent work of an individual or department but a systematic project involving all project departments and specialties, requiring full participation to fully leverage BIM' s technical advantages.

(3) BIM technology can transform traditional construction concepts and lead building information technology to higher levels. Its comprehensive application will greatly improve the integration level of building management.

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Key Words: Software and Hardware Configuration; Organization and Planning of BIM System; BIM Technology; Project Management; Application

Note: Figure translations are in progress. See original paper for figures.