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Application of BIM Technology in the Zhengzhou Museum New Building Project (Postprint)

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Abstract

Large-scale venue projects often feature complex geometries, complex structures, and numerous specialties. Actual construction also faces challenges such as difficult construction organization, extensive process interleaving, and high construction difficulty; the application of BIM technology can effectively address these issues [citation deleted]. This paper primarily introduces how the Zhengzhou Museum New Hall project utilized BIM technology during the design and construction phases to resolve the aforementioned problems, thereby achieving high-standard design, high-quality construction, and high-level management. Through this comprehensive application, the project established an owner-driven, whole-process, multi-stakeholder collaborative BIM implementation system, developed methodological experience for transitioning from design BIM to construction BIM, and summarized a management model that integrates BIM with construction production business processes. The study proposes novel management approaches for spatial positioning of complex steel structures during the design phase, “detailing + fabrication + construction” technology for curved curtain walls, and BIM-based “schedule + resources + work” planning management. This project explores the application of BIM technology in large-scale venues through practical implementation, summarizes the contributions of BIM technology in facilitating project delivery through its application across various disciplines, and provides reference materials and robust support for future BIM technology applications in large-scale venue engineering projects.

Full Text

Preamble

Application of BIM Technology in the New Zhengzhou Museum Project

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Abstract

Large-scale venue construction projects are characterized by complex architectural forms, intricate structural systems, and numerous specialized disciplines. Construction implementation faces significant challenges in organization, process integration, and technical difficulty. Building Information Modeling (BIM) technology offers effective solutions to these challenges. This paper presents the comprehensive application of BIM technology during the design and construction phases of the new Zhengzhou Museum project, demonstrating how it resolved critical issues and enabled high-standard design, high-quality construction, and high-level management. Through this integrated application, the project established an owner-driven, full-process, multi-stakeholder collaborative BIM implementation system. The experience gained includes successful transition methodologies from design-BIM to construction-BIM and management models that integrate BIM with construction production workflows. The project introduces innovative management approaches for spatial positioning of complex steel structures during design, “deepening-processing-construction” technology for curved curtain walls, and BIM-based “progress-resources-work” planning management. This exploration provides valuable reference materials and robust support for future BIM applications in large-scale venue projects.

Keywords: BIM; Revit; Design-Construction Integration; Planning Management

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1. Project Overview

1.1 Project Description

The new Zhengzhou Museum has a total construction area of approximately 147,000 m², with two underground floors and five above-ground floors, reaching a height of 67.797 m. Upon completion, it will become the second largest museum in China. The project embodies the design concept of “Crown of China, Crown of the Yellow Emperor,” using the imperial crown symbolizing Yellow Emperor civilization as its architectural prototype while incorporating the imagery of a treasure bowl to create powerful curved dynamic forms that express the splendid cultural history of Central China. The structural system employs a hybrid framework of “steel-reinforced concrete columns + steel-reinforced concrete beams + core tube steel-concrete composite shear walls,” with the roof structure combining bolted spherical grid systems and bidirectional orthogonal steel pipe trusses. The project rendering is shown in Figure 1 [Figure 1: see original paper].

Figure 1 Project rendering of the new Zhengzhou Museum

1.2 Key Challenges

1. **Design Complexity:** The architectural form is highly complex, featuring an arched and sloped steel roof. The facade consists of curved curtain walls using double-curved glass, irregular GRC panels, ceramic plates, and aluminum panels with intricate detailing, including a bowl-shaped GRC curtain wall on the north side. Spatial positioning of the steel structure is challenging due to numerous functional zones.
2. **Construction Complexity:** The project includes ten irregular steel-reinforced concrete core tubes with complex steel components such as steel plate shear walls and steel pipe columns. The intersection nodes between steel structures and reinforcement bars are particularly complicated, involving substantial 工程量.

3. **Tight Schedule:** The project had to be completed for the National Ethnic Games, with a total construction period of only 20 months, creating significant time pressure.
4. **Extensive New Technology Application:** The project implemented 10 major categories and 39 sub-items of the construction industry' s top ten new technologies, including numerous innovative applications such as coupling beam dampers and buckling-restrained braces.

2. BIM Organization and Application Environment

2.1 BIM Application Objectives

The overall objective was to utilize BIM technology to reduce costs, optimize schedules, and create a high-quality project. Specific implementation targets included:

1. **Design-Construction Integration:** Strengthen integrated design-construction workflows to reduce comprehensive costs.
2. **Refined Design:** Apply BIM technology to resolve design issues proactively, improve building quality, and facilitate construction.
3. **Lean Construction:** Implement BIM-enabled fine management practices.
4. **Innovative Application Exploration:** Build a smart construction site and explore integration of VR, IoT, and other technologies with BIM.

2.2 Implementation Plan

The project established a BIM application guide (defining BIM objectives, expected outcomes, and stakeholder responsibilities), a BIM implementation plan (specifying application points and methods tailored to project characteristics), and BIM application regulations (establishing implementation rules with reward and penalty measures to enhance management) [1].

2.3 Team Organization

The project created a BIM management organizational structure led by the construction unit with participation from design, construction, supervision, and consulting parties, as shown in Figure 2 [Figure 2: see original paper]. The design unit played a pivotal role, providing construction-ready BIM models that were reviewed by the owner' s BIM consultant to achieve models suitable for construction deepening. This bridging function ensured both drawing integrity and construction model coordination.

2.4 Software and Hardware Environment

The core software platform was Revit 2016 for architectural, MEP, subcontractor, and site layout modeling. Tekla was used for steel structure modeling and

detailing, Navisworks for clash detection, Fuzor and Lumion for architectural design, model review, walkthroughs, animations, and VR applications. MIDAS handled structural analysis, Glodon BIM5D managed project schedule, quality, safety, technology, commercial, and material aspects, while Glodon GMJ created formwork and scaffolding models. Hardware included computers, touch-screen displays, large-screen TVs, VR headsets, and drones.

3. BIM-Based Design Management

The design unit delivered BIM models suitable for construction deepening, which were then reviewed by the owner's BIM consultant to achieve construction-ready models. The design unit served as a critical link, responsible for both drawing integrity and coordination with contractors to complete construction models.

3.1 Design Phase Management Measures

During the design phase, the design unit established modeling standards and operational guidelines based on the construction unit's requirements. The unit clarified roles and responsibilities, optimized BIM implementation workflows, defined BIM work processes, and quantified BIM tasks to effectively organize complex BIM implementation activities into manageable units.

3.2 Design Phase Implementation Challenges

1. **Complex Steel Structure Positioning:** Inspired by the Yellow Emperor's crown, the museum's massive scale and large-span steel structure design presented significant positioning challenges, as shown in Figure 3 [Figure 3: see original paper]. BIM implementation adopted an "assistant design" approach to ensure drawing quality, spatial requirements, and structural calculations while anticipating construction issues to protect schedule performance [2].

Figure 3 Architectural concept diagram

2. **Curtain Wall Deepening:** Previous projects often had ambiguous designs where deepening work lagged and impacted construction. This project employed parametric BIM design to enhance early-stage curtain wall design depth, providing accurate data for subsequent detailing and installation to ensure schedule compliance and cost savings. For steel structures, parametric BIM modeling converted calculation models into comprehensive Revit application models for multi-disciplinary use, as shown in Figure 4 [Figure 4: see original paper]. The steel roof BIM model established during design determined detailed member configurations, completed complex component design and optimization based on architectural forms, and resolved previous issues of non-intuitive design and delayed detailing.

Figure 4 Steel structure and curtain wall models

3. **Spatial Analysis:** With over 90 distinct functional zones, each space required individual clearance height analysis considering floor-to-ceiling heights, maximum beam depths, and finishing schemes. Comprehensive factors including MEP installation and maintenance spaces were evaluated for MEP coordination and clearance optimization, as shown in Figure 5 [Figure 5: see original paper].

Figure 5 Floor height analysis table and optimization model

4. BIM-Based Construction Management

After project commencement, the general contractor served as the overall coordinator, organizing all parties to implement BIM technology.

4.1 Deepening Design

The construction phase followed the principle of “who constructs, who deepens.” The general contractor organized drawing and model review meetings, integrated subcontractor requirements, and delivered consolidated models to subcontractors for deepening. Results were coordinated among multiple parties, reviewed by the construction unit, and approved by the design unit before stamp issuance for construction. This process produced over 5,600 approved deepening drawings and material statistics [3].

The complex intersections between steel structures and reinforcement bars posed significant construction challenges. Steel structure deepening models generated node details that ensured efficient construction, saving approximately 16 days and 677,000 RMB in costs, resulting in a provincial-level construction method award and first prize in Henan QC activities.

4.2 Construction Management Applications

The construction phase achieved fine management through BIM, cloud platforms, big data, IoT, and smart equipment. Daily management activities including schedule, quality, safety, and cost control were conducted based on BIM models and data. A BIM-based collaborative platform resolved previous issues of low communication efficiency and difficult data storage [4].

1. **Site Layout Management:** The complex site conditions included simultaneous construction of four centers, underground utility corridors, subway lines, and roads, with limited space preventing circular traffic flow. BIM technology enabled phased site modeling and layout planning (Figure 6 [Figure 6: see original paper]), optimizing temporary construction models and quantity takeoff. This improved communication efficiency by 80%, ensured rational site layout, and controlled temporary construction costs within 1% of contract value.

Figure 6 General layout at different construction stages

2. **Formwork and Scaffolding Design:** The project involved 14,000 m² of high-formwork scaffolding with maximum heights of 24m and complex stepped configurations. Formwork software optimized layout and provided 3D visualization for site guidance. Material lists generated through this process saved approximately 90,000 RMB in rental costs compared to conventional calculations.
3. **Curtain Wall Construction:** Survey points extracted from BIM models were imported into software and laid out using BIM-enabled surveying robots. These robots used infrared lasers to automatically align with real-world points, accurately translating BIM models to the construction site and improving both precision and efficiency. GRC curtain wall panels were manufactured by importing detailed BIM models into 3D CNC carving machines, ensuring component styles and textures met design and installation requirements. Installation sequences were determined through simulated construction to guide efficient site operations, as shown in Figure 8 [Figure 8: see original paper].

Figure 7 Measurement control points

Figure 8 Construction simulation

4. **Masonry Layout:** To avoid material waste, BIM masonry layout technology generated detailed brick arrangement drawings for 7,300 m² of walls. Combined with site management, this reduced masonry waste from the traditional 7% to 2%. The process involved one-click opening creation in the architectural-MEP integrated model using Revit plugins, followed by virtual masonry layout in BIM5D software for site fabrication and installation.
5. **Document Management:** Project technical documents were uploaded to a cloud platform accessible via mobile devices and web browsers. A process library created from construction schemes has achieved 8,350 accesses and downloads to date.
6. **Schedule Management:** A BIM-based schedule management process was established (Figure 9 [Figure 9: see original paper]). The master schedule was developed through construction simulation, from which work plans were derived. During implementation, planned versus actual progress was compared, and resources were allocated for fine management of work sections. Data was uploaded to the cloud platform for weekly review meetings to monitor implementation. This system of shared responsibility, layered assessment, and timely incentives established a robust schedule management framework and supported comprehensive performance evaluation. Despite being the last of four centers to start, the project has now caught up with the others in physical progress.

Figure 9 BIM-based schedule management process

7. **Quality Management:** With large floor areas creating complex quality management challenges, the project implemented a comprehensive quality and safety issue tracking system based on the BIM model. All personnel were integrated into the system, establishing a complete quality-safety management workflow (Figure 10 [Figure 10: see original paper]). Problem resolution time averaged one day compared to 2-3 days in conventional projects, achieving a 94% resolution rate—13% higher than typical projects. The platform integrated online and offline processes, automatically generating rectification forms and quality analysis reports for meeting presentations.

Figure 10 BIM-based quality management

8. **Safety Management:** Building on quality management workflows, safety management added patrol points near large equipment and hazard sources with scannable QR codes. Inspectors conducted regular checks, scanning codes to submit electronic records. The project also employed VR safety education equipment to enhance safety training.
9. **Commercial Management:** The model was divided into work sections for material quantity takeoff, precisely linking each section with schedule plans to generate monthly material plans [5]. Concrete was issued using quantity limits based on model calculations to strictly control subcontractor material waste, while smart weighbridges monitored material deliveries in real time. Concrete waste was consistently controlled within tolerance limits, achieving a 1.3% savings rate. Monthly comparisons between planned quantities, model quantities, and actual consumption generated resource analysis tables for dynamic cost control.
10. **Other Applications:** The project explored smart site technologies by integrating BIM5D with a smart site cloud platform to achieve comprehensive coverage of schedule, labor, quality, safety, and environmental management. The platform integrated surveillance cameras, patrol systems, tower crane monitoring, dust detection, and BIM5D data for real-time monitoring of tower operations, power consumption, labor forces, site progress, and safety-quality issues. Two-dimensional barcodes automatically generated for components enabled express-style tracking, with status updates scanned at each workstation.

5. Project Application Results

BIM application during the design phase achieved measurable benefits: design time savings of 75 days, site construction time savings of 80 days, and indirect benefits of approximately 4.8 million RMB. During construction, direct economic benefits reached 1.31 million RMB, with site construction time savings of 51 days and indirect benefits of approximately 15.3 million RMB.

6. Conclusions

This paper has elaborated on the application of BIM technology in the new Zhengzhou Museum project. The project established an owner-driven, full-process, multi-stakeholder collaborative BIM implementation system, developed methodologies for transitioning from design-BIM to construction-BIM, and summarized management models integrating BIM with construction production workflows.

6.1 Innovation Points

1. Spatial positioning of complex steel structures during the design phase provided strong support for construction, promoting design-construction integration without secondary 返工.
2. The “deepening + processing + construction” technology for curved curtain walls ensured high fidelity between construction and design models, facilitating high-quality construction.
3. BIM-based “progress + resources + work” schedule management enabled fine project management, achieving goals of cost savings, schedule optimization, and high-quality delivery.

6.2 Lessons Learned

1. If the construction unit lacks in-house BIM capabilities, it should engage qualified consulting firms for auxiliary management.
2. The design unit’s work division and model decomposition should be planned early.
3. The construction unit’s BIM application strategy should be clarified at project commencement.
4. BIM capabilities across all participating units should be comparable; otherwise, coordination workload increases significantly.

References

- [1] Li Jiulin, Wang Yong. Exploration of BIM application in large-scale general contracting projects[J]. Journal of Civil Engineering and Information Technology, 2014, 6(5): 61-65.
- [2] Wu Wenyong, Jiao Ke, Tong Huibo, Chen Jianjia, Huang Gaosong. Forward design method and software implementation of building structures based on Revit[J]. Journal of Civil Engineering and Information Technology, 2018, 10(3).
- [3] Wu Wenyong, Jiao Ke, Tong Huibo, Chen Jianjia, Huang Gaosong. Forward design method and software implementation of building structures based on Revit[J]. Journal of Civil Engineering and Information Technology, 2018, 10(3).
- [4] Wu Wenyong, Jiao Ke, Tong Huibo, Chen Jianjia, Huang Gaosong. Forward design method and software implementation of building structures based on Revit[J]. Journal of Civil Engineering and Information Technology, 2018, 10(3).
- [5] Tang Haiyan, Liu Ronggui, et al. Construction of engineering construction

cost prediction system based on BIM5D[J]. Journal of Engineering Management, 2015, 29(4): 107-112.

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