The Application of Digital Technology in Public Building-The Han Hall Project at the Wuhan International Expo Center

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Abstract. This article takes the Han Hall project at the Wuhan International Expo Center as a case study to illustrate how digital technology has been applied in various stages of the construction process, including conceptual design, construction drawing design, engineering construction, and operation and maintenance management. It demonstrates the role of digital technology in the construction of public buildings.

Keywords: Digital Technology in EPC; Operational Management

1. The Current Status of BIM Technology Unitilzation Demostically and Abroad

The United States is at the forefront of international research on Building Information Modeling (BIM). As early as 1975, the concept of BIM was introduced by Chuck Eastman, often referred to as the ‘father of BIM,’ who proposed ‘a computer-based description of a building’ to enable visualization and quantitative analysis of construction projects, thus enhancing efficiency. This marked the inception of BIM.

Internationally, various standards and specifications related to BIM technology have been established in the civil engineering and construction industries, supported by governments and research institutions. These standards have been put into practice and widely promoted, demonstrating significant practical efficacy. Notable examples include the ‘General Services Administration BIM Guide United States’(2007), the United States National BIM Standard (2007), ‘the National Guide for Digital Modeling’ in Australia (2009), and ‘the Advance Emerging Capital Limited (the United Kingdom) BIM Standard’ (2009). Similarly, several European countries, such as Germany, Norway, and Finland, have developed corresponding technical guidelines and usage instructions for BIM technology, tailored to their specific developmental contexts

In China, the concept of BIM was introduced in 2001, and comprehensive systematic introduction of BIM technology to the Chinese audience was provided in 2004 by Songpei Ge and others from Tsinghua University in their paper titled "A New Concept of Information Technology Application in Construction Industry — BIM." Since then, BIM technology has gradually been researched and applied domestically. In December 2016, the Ministry of Housing and Urban-Rural Development issued the "Unified Standard for Building Information Modeling Application," marking a breakthrough in China's application standards for building information modeling. Currently, the research directions for BIM technology in China have become progressively clearer. Scholars such as Qu Xiao and Xiangfeng Yang[1] argue that the deep integration of BIM technology with technologies such as drone-based reality modeling, virtual reality (VR), Geographic Information System (GIS), and cloud computing has expanded the application of BIM technology beyond design, extending it to the entire lifecycle of construction projects. Additionally, scholars like Min Xu suggest that utilizing BIM technology for detailed design of mechanical and electrical systems, guiding construction installation, conducting quality control, and optimizing material

procurement can significantly reduce construction costs and time, positively impacting construction quality.

Further research by scholars like Changtao Hua[2] indicates that implementing construction simulation technology through BIM can prevent conflicts between various professional roles, strengthen control over construction technology, and reshape management organizational structures based on BIM, thereby enhancing the level of quality management in construction. Lisong Zhang[3] conducted research on the implementation of Building Information Modeling (BIM) throughout the lifecycle of a maternity and child health hospital project. This study involved a comparative analysis of BIM application scenarios between hospital construction projects and new civil building projects. The findings indicated a higher cost-saving rate with BIM in hospital expansion projects, accompanied by shortened project cycles.

Moreover, BIM technology demonstrated particular proficiency in information integration. Similarly, Qian Liu's[4] study focused on BIM-based operation and maintenance management of the T3A terminal at Chongqing Jiangbei International Airport. The research revealed that BIM-based operation and maintenance management of airport terminals can enhance efficiency in management, elevate service standards, reduce costs, and mitigate safety risks.

Currently, BIM technology is primarily used to assist in the construction of large-scale public buildings and high-rise projects in China[5], such as the National Stadium, National Cyber Security Center, Shenzhen Ping An Center, Shanghai Center, new airport terminals, and Wanda projects. By utilizing BIM technology to pre-plan simulations of complex nodes, irregular steel structures, curtain walls, and large-scale mechanical and electrical equipment and pipeline installations, previously difficult-to-manage design errors can be detected early, and issues such as discrepancies, omissions, collisions, and deficiencies can be addressed through coordinated management of various professional three-dimensional models, thereby reducing construction costs and yielding more tangible economic benefits.

Furthermore, initiating BIM technology application in the design phase enables early detection of problems and identification of solutions, gradually expanding the application of BIM to the operation and maintenance phases, thereby establishing project lifecycle management based on BIM technology.

2. Project Overview

The Han Hall of the Wuhan International Expo Center (hereinafter referred to as ‘Han Hall’) is situated in the Four New Riverside Area of Hanyang District, Wuhan.

The Han Hall, a multifunctional public building within the Wuhan International Expo Center ('Expo'), enhances the center's capacity for exhibitions, conferences, and theaters. With a total area of 56,400 square meters and standing at 51 meters tall across four floors, it is centrally located within the Expo, surrounded by a sunken garden. The ground floor provides access to an elevated parking lot, while the first floor includes a registration foyer and a central exhibition hall connected to the Expo platform. The second floor features a conference hall, stage area, and lobby with over 2,300 seats, and the third floor houses additional seating and facilities. Designed to represent Wuhan, highlight the Expo, and promote Jingchu culture, the Han Hall embodies the post-pandemic aesthetic of the city, integrating cultural heritage with contemporary design principles, symbolized by "majestic mountains and rivers, and plum blossoms heralding spring.

(a) Schematic Renderings (b) Aerial Photograph

Fig.1 Schematic Renderings in the Sheme Design Phase & Aerial Photograph of Completed Construction

2.1 The project's characteristics

This project adopts the EPC (Engineering, Procurement, and Construction) engineering general contracting construction model, jointly implemented by CITIC Design and Wuhan Construction. The project pre-positions the system architecture of intelligent construction and smart operation and maintenance to the design stage. Through the integration of a comprehensive BIM (Building Information Modeling) model across all disciplines, the entire project's virtual construction and visual comparison are completed. BIM technology is integrated throughout the entire lifecycle of scheme design, construction drawing design, construction process, and operation and maintenance.(Fig.1b）

In EPC (Engineering, Procurement, and Construction) general contracting projects, the volume of project construction information is often vast, involving numerous stakeholders, and characterized by large-scale construction. Against the backdrop of rapid advancements in information technology, traditional information management models are no longer sufficient to meet the new objectives of EPC general contracting projects, which aim to enhance project information management through comprehensive information integration. BIM (Building Information Modeling) technology provides reliable technical support for information management throughout the entire lifecycle of construction projects, enabling effective integration of project information and facilitating collaborative operations among stakeholders to improve construction efficiency[6].

2.2 Analysis of Key Challenges and Difficulties

The Han Hall of the Expo is an EPC project, involving a wide range of trades and specialties, while facing pressures such as tight deadlines, cost constraints, and high levels of attention. As one of the members within the EPC consortium and the full-process design service provider, CITIC Design fully leverages its long-standing technical expertise and digital transformation advantages. It has assembled a team of highly skilled professionals, with a total of 103 designers across 20 disciplines, who have completed 20 external expert reviews, 120 meetings, 180 reports, and 300 site visits. Overcoming numerous seemingly insurmountable challenges, they have ensured the successful hosting of several major conferences.

The specific issues in various stages of engineering construction can be categorized into the following four aspects: (1)How to quickly produce results to assist decision-making during the scheme design phase; (2) How to further improve the efficiency of collaborative design between traditional construction drawings; (3) How to further enhance management efficiency and engineering quality during the construction process; (4) How to integrate BIM technology with smart building concepts. This article will sequentially discuss how to address these issues through the application of BIM technology.

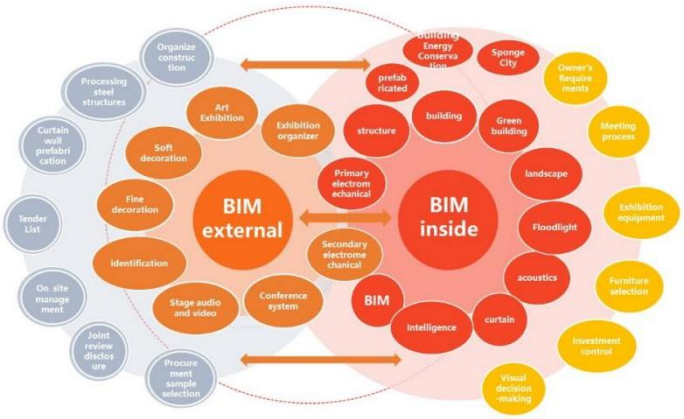

Fig.2 Illustration of Comprehensive Multi-Disciplinary Collaborative Mechanism with Multiple Loops

3. Application of Digital Design

During the design phase of the EPC engineering general contracting project, the positive characteristics of BIM design can be fully utilized. Through various stages of design analysis, three-dimensional visualization design, data retrieval, multi-disciplinary collaboration, and clash detection using BIM applications, the rationality and scientific nature of drawing design are enhanced.

During the construction phase, the principle of 'modeling reality consistency' is employed, ensuring close integration between the model and the site to guarantee high-quality construction, thus contributing to the advancement of "Chinese construction" [7].

3.1 Analysis of Key Challenges and Difficulties

The digital solutions for the scheme design phase are as follows:Decision-making during the scheme design phase is often the most challenging, requiring designers to make scientific and rapid decisions. In traditional projects, the schematic design phase involves nonlinear modeling, spatial layout deliberation, organization flow determination, and spatial scale discussion, all of which need to be demonstrated within a short time. We utilize BIM parametric design technology, wherein, for the Han Hall project, different graphical schemes are generated by modifying the numerical values of corresponding functions in the software. This facilitates rapid selection for designers and owners, thereby shortening the decision-making cycle.

The high net clearance within the project's internal spaces makes it challenging to grasp the scale effects of components. Traditional methods involve comparing multiple rendered images, which is time-consuming and inefficient. BIM technology enables us to simulate the human perspective of the lobby space through software, allowing for the modification of escalator arrangements and careful consideration of spatial relationships. This enables quick responses and the derivation of schemes that achieve the best effects while balancing safety and cost-effectiveness.

3.2 BIM Application in the Construction Drawing Phase

In traditional construction drawing refinement, coordination among disciplines is often inefficient, requiring significant time to verify deficiencies. We address this using BIM's collaborative workflow, integrating all disciplines into a single model. Clash detection and model reviews identify clashes in advance, providing timely feedback and improving efficiency. Additionally, there is an improvement in design quality. In traditional design, net clearance expression lacks intuition, making it difficult to identify issues. However, by using BIM technology, after confirming the layout plan with the construction unit, we integrate equipment pipelines to create a coordinated model. After considering decorative surfaces, we derive net clearance analysis floor plans, ensuring design quality.(Fig. 3)

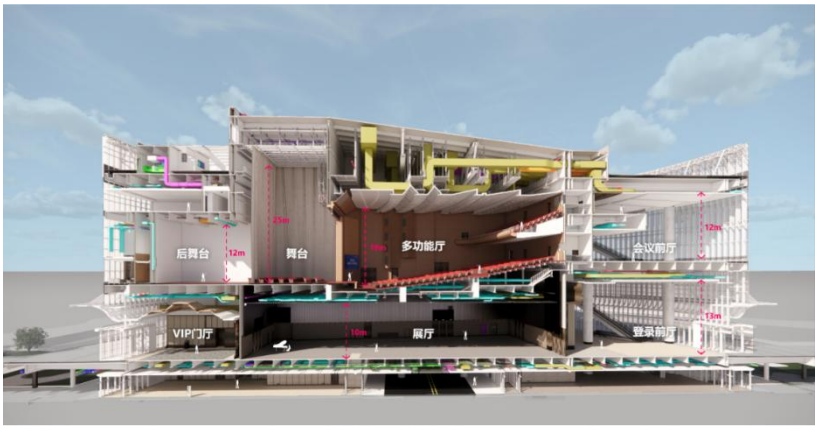

Fig.3 Net Spatial Clearances and Pipeline Layouts in Various Zones

3.3 BIM Application in the Construction Phase

During construction, we prioritize on-site model coordination meetings and briefings, as well as construction management. Firstly, after finalizing the design model, we hold on-site BIM coordination meetings involving design, construction, supervision, and other relevant units to resolve clashes, complexities, and ensure model accuracy. This facilitates using the model for construction guidance. For on-site management, we upload the BIM model to a platform accessible via web and mobile. On-site users refer to the mobile platform to cross-reference the lightweight BIM model with construction processes, reporting issues(Fig.5) with photos and descriptions. Administrators on the web platform make timely decisions, coordinating resources to enhance construction quality and efficiency.


Fig.4 Mobile End Platform for On-Site Users

3.4 BIM Application in the Operation and Maintenance Phase

In terms of building operation and maintenance management, we have developed a comprehensive digital solution known as the Digital Intelligent Architecture Operations Platform (DIA) (referenced as Fig.5). DIA system, led by design, incorporates smart and digital architectural concepts into buildings during the project planning and design phase. This results in the formation of a comprehensive maintenance and operation platform that combines a digital large screen web interface, intelligent operation cloud platform, and integrated mobile application platform, serving maintenance and operation personnel as well as daily users. Within the DIA system, we have integrated various intelligent applications based on the BIM model, including energy management, environmental monitoring, intelligent lighting, HVAC, smart security, smart consumption, facility management, intelligent work orders, touchless access, smart meetings, smart dining, smart libraries, smart parking, smart living, and smart robotics, comprising over fifteen intelligent application modules. This enables the rapid establishment of a digital intelligent building application platform,

facilitating the management of "large properties" operations. The DIA system directly enhances the value of buildings and reduces maintenance costs, marking the gateway to a new era.

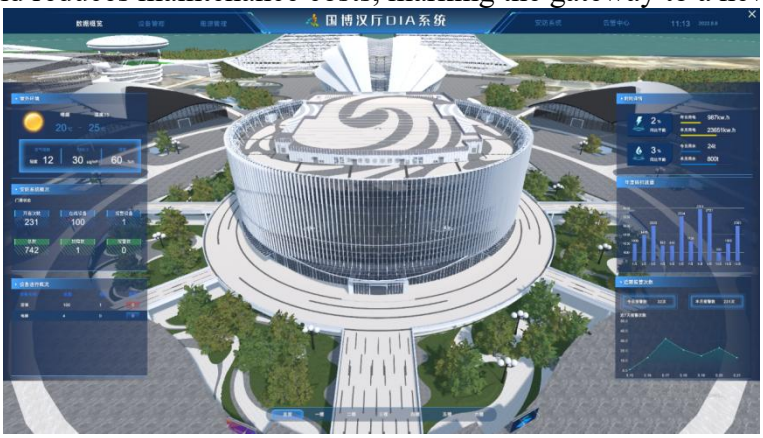

Fig.5 The Big Screen Display of the DIA system for The Han Hall at the Wuhan International Expo Center

4. Conclusion and Outlook

This article focuses on how BIM technology addresses challenges in project design, construction, and maintenance. From refining functionality in conceptual design to interdisciplinary collaboration in construction drawing design and visualizing construction processes, BIM is crucial. It also provides smart building solutions during maintenance, ensuring high-quality and efficient completion of the Wuhan International Expo Center Han Hall project.

In this era of rapid technological advancement, BIM technology has become the cornerstone for the digitalization and intelligence of the construction industry. Whether it involves the transformation of architectural aesthetics and process technology, the improvement of construction efficiency and quality, or the comprehensive application throughout the building's lifecycle, BIM technology can adeptly address these challenges. With just one model, BIM technology can span the entire construction process. BIM technology will drive the construction industry towards a new, standardized mode of operation and usher in a transformation in the entire construction activity, ultimately promoting a paradigm shift in the industry.

References

[1] Qu Xiao, Xiangfeng Yang. ‘BIM Facilitating the Upgrade of Project Lifecycle Management.’ China Construction Informatization, 2019(18): 16-19.

[2] Changtao Hua. ‘Application Research of BIM Technology in Project Construction Quality Management.’ (Master's thesis) Anhui Jianzhu University, 2020.

[3] Lisong Zhang . ‘Research on Full Lifecycle Management of Medical Building Installation Projects Based on BIM Technology.’ (Doctoral dissertation) Shandong Jianzhu University, 2021.

[4] Qian Liu . ‘Evaluation Study on BIM-based Operation and Maintenance Management of Chongqing Airport T3A Terminal.’ (Master's thesis) Southwest Jiaotong University, 2022.

[5] Qingtao Yu . ‘Exploration of BIM Technology Application in Engineering Construction.’ Value Engineering, 2018, 37(26): 241-244.

[6] Ting Wang . ‘Research on Information Management System of EPC Projects Based on BIM.’ (Master's thesis) Xi'an University of Science and Technology, 2018.

[7] Zhong Li , Shuying Yang , Qiuwan Cai. ‘Application Research of BIM Forward Design in Design Management of EPC Projects.’ Guangdong Civil Engineering and Architecture, 2022, 29(12): 5-9. DOI:10.19731/j.gdtmyjz.2022.12.002.