Journal of Civil Engineering and Urban Planning (2024) DOI: 10.23977/jceup.2024.060214
Clausius Scientific Press, Canada ISSN 2616-3969 Vol. 6 Num. 2

Application of BIM in Airport Reconstruction Projects

Wu Wen[1,a,*], Wang Jing[2,b], Zhang Yutao[3,c]

[1]Civil Aviation Engineering Consulting Company of China, Shunyi District, Beijing, China
[2]Shandong Airport Construction Management Group, Jinan, Shandong, China
[3]Nanjing University of Aeronautics and Astronautics, Jiangning District, Nanjing, Jiangsu, China
[a]401058942@qq.com, [b]jnwangjing@126.com, [c]2219634118@qq.com
[*]Corresponding author

Keywords: Airport; BIM technology; renovation and expansion; four-type airport

Abstract: BIM technology has been widely used in civil engineering. In response to the Civil Aviation Administration's promotion of intelligent construction and industrialized development of building, this paper analyzes the current application status of BIM technology in airport engineering. Considering the characteristics of airport renovation projects, such as integration, complexity, and continuous operation without interruption, the advantages of BIM technology in airport renovation are proposed. This paper analyzes the key technical points of BIM in the design, construction, and operation and maintenance stages from the perspectives of application scope, content, and management. Finally, taking the project of Jinan Yaoqiang International Airport as an example, this paper expounds the application effectiveness of BIM technology in the airport renovation project, summarizes the applied technology and benefits, and demonstrates that it can achieve more efficient and quality-guaranteed management and contribute to the construction of a four-type airport.

1. Introduction

With the development of the economy and the advancement of civil aviation technical services, aircraft have gradually become one of the important modes of transportation, and airport construction in China has also been continuously advancing. By the end of 2022, there were 254 transport airports (excluding Hong Kong, Macau, and Taiwan) in China [1]. Airport engineering is a complex multi-body project, encompassing a wide range of scopes. It involves various professions such as architecture, structure, water supply and drainage, heating and ventilation, electrical, intelligence, civil aviation weak current, luggage systems, interior decoration, landscaping, signage, roads, bridges, transportation, and more. Airport engineering often exhibits the following characteristics: (1) Project sites are often located in remote areas, with extensive and complex management content and high requirements; (2) Construction projects integrate intelligent and information systems, with intricate interrelationships; (3) A wide range of professional involvement, extensive knowledge, and high technical difficulty. Therefore, the utilization of BIM has become an urgent need which can create a globally modern smart aviation city that is safe, efficient, automated, intelligent, green, and energy-saving [2,3].

In recent years, the demand for air transportation has continued to grow, and a lot of airports are facing the need to renovate and expand their functional areas. In such projects, more severe challenges are faced in terms of construction cycle, safety, schedule, and quality management. Based on such needs, the introduction of BIM technology in renovation and expansion projects can help achieve more efficient and quality-guaranteed management and control.

2. The Application Status of BIM in Airport Engineering

China's airports have been closely integrated with BIM, making good use of BIM's forward-looking planning and establishing detailed standards. For instance, in the Ezhou Airport[4] and Daxing Airport projects, BIM has been incorporated as an integral part of the initial project bidding process in Ezhou Airport. Comprehensive BIM work has been carried out in multiple dimensions and across various specialties, strictly adhering to relevant regulations and management standards. In the design of project models, specific frameworks are classified according to component types, and detail models are defined. Each component is named using multi-digit encoding numbers, enabling more precise model implementation and facilitating the querying of component attributes during the operation and maintenance phase[4,5].

In the Istanbul New Airport project, the implementation of Design-Build was facilitated by BIM's efficient coordination and information sharing, significantly enhancing construction quality and management efficiency[6,7]. During the construction process, the high efficiency of the BIM system in handling and recording RFI (Request for Information) and design changes further accelerated the approval and execution processes for Fast-Tracking and Design-Build projects. The detailed and accurate information provided by the BIM model enabled design and construction teams to quickly identify and address on-site issues, reducing unnecessary delays.

3. Key application points of BIM in airport renovation and expansion

How to fully leverage the value of BIM informatization in airport construction projects and assist construction in project management using BIM technology is the focal point of BIM work. BIM technology can be used to enhance the quality of engineering management, improve the efficiency of project control, and reduce communication costs.

3.1. BIM Application Content

The airport reconstruction project integrate multiple disciplines such as architecture, structure, electromechanical, municipal, road, airport runway, navigation lighting, luggage system, etc. Through the application of BIM technology in the entire process and life cycle of project design, construction, operation and maintenance, the accuracy, collaboration, and traceability of airport engineering project data are ensured, and the overall digital asset transfer of the project is realized. This provides basic data for smart construction sites and airport smart operation and maintenance, and improves the quality and efficiency of project management. The following content is achieved through the application of BIM technology:

(1) Auxiliary optimization design

Fully considering the BIM application requirements, we should clarify the requirements for designing BIM models in the early stage. Then BIM models for multi-disciplinary comprehensive applications in the design stage can be used, and errors and deficiencies in the design can be found and modified. Various professional models are optimized and some special applications are carried out such as analysis of building interior clear height, laying out traffic flow and passenger flow in the terminal area, and assisting in improving the quality of design drawings.

(2) Providing information infrastructure for intelligent construction

BIM models can achieve multi-disciplinary integration and coordination. By carrying out BIM deepening and technology application, problems in construction drawings can be identified. Construction plans, on-site construction quality, progress can be planed as early as possible, and on-site construction rework can be minimized. Of course, we can reduce waste, reduce costs, improve project quality and efficiency from the source.

(3) Providing an information-based foundation for intelligent operation and maintenance

Using the visualization and informatization of BIM technology to assist in the intelligent operation and maintenance of the project in the later stages [8,9], the BIM model can reduce the "information cliff" that occurs during the handover of results at various stages, ensuring the continuity of information. In the operation and maintenance stage, various equipment parameters required for operation and maintenance are integrated to provide data support for achieving three-dimensional digital operation and maintenance.

3.2. BIM Application Scope

(1)Application across all specialties

The term "full-discipline application" refers to the various disciplines encompassed by individual and unit projects within the terminal area, airfield area, and work area of the project.

(2)Application of the whole process

The BIM application is carried out in the design stage, including scheme design, preliminary design, construction drawing design, and the construction stage, and operation and maintenance preparation. According to the actual needs of each stage, we should determine the depth and application content of BIM model in different stages to maximize the value of BIM.

(3)All members participate

Full participation refers to the participation of all participating units in BIM work, including the construction unit, design unit, construction unit, including the general contractor, professional engineering, equipment supply unit, supervision unit, whole-process engineering consulting unit, BIM technical service unit, etc., and cooperation with other units in BIM implementation.

3.3. BIM Application Organization Management

(1) BIM organizational structure

The construction unit is responsible for the overall arrangement of BIM work and determining the organizational structure; the whole-process engineering consulting unit assists the construction unit in participating in the whole process, and is responsible for organizing and planning the implementation of BIM, as well as coordinating among participating units; each unit is responsible for implementing the corresponding BIM application according to their division of responsibilities.

(2) BIM collaborative workflow

The design phase is in the charge of the design unit, while the construction unit is responsible for controlling the overall situation. The construction phase involves the construction unit collaborating to enter various information into the construction BIM model, and updating the BIM completion model. The operation and maintenance preparation stage involves the BIM technical service unit responsible for specific BIM implementation work based on operation and maintenance needs, with review by the construction unit and the whole-process engineering consulting unit.

4. Application Cases of BIM in Airport Reconstruction and Expansion

4.1. Project Overview

Jinan Yaoqiang International Airport [10] is located in northeast of Jinan City, and is a distinctive regional hub airport. The total investment budget for the second phase of the Jinan Yaoqiang Airport expansion project is approximately 43.905 billion CNY, mainly including the construction of two new runways with a length of 3,600 meters and a width of 45 meters, 170 parking aprons, as well as the T2 terminal building, comprehensive transportation center, parking building, air cargo terminal and some supporting buildings.

Project difficulties: large scale, high requirements, multiple disciplines, multiple processes, long cycle, multiple collisions and intersections, different functional requirements and complex functions for various single building types such as terminal area, flight area, work area, etc.

4.2. BIM Application Overview

During the implementation of BIM, it is necessary to reasonably split BIM models and reduce the number of individual model file components to make the model software operate more smoothly and facilitate model modifications. At the same time, establishing a unified view template and unified grid for the project will facilitate the accurate integration of split BIM models from various disciplines, which is beneficial for the accurate positioning of model components.

The delivery form, content, review points, handover methods, processes, and handover nodes of BIM results at various stages is established in the project BIM standard. And a complete BIM handover model and management system are formed.

4.3. BIM application effectiveness

The following BIM design models were created during the design phase of this project: (1) Terminal area: BIM models for buildings such as T2, the comprehensive transportation center, and parking buildings, as well as towers and annex buildings, comprehensive pipe galleries, and roads; (2)Airfield area: BIM models for various buildings such as navigation lighting engineering, fire rescue engineering, security engineering, airport road engineering, drainage engineering, earthwork engineering, road and bridge engineering, power supply engineering, communication engineering, underpass channels, and supporting individual building projects; (3) Work area: BIM models for various buildings such as airport comprehensive command and support rooms, and reconstruction of air traffic control comprehensive management rooms, as well as elevated structures, roads, and comprehensive pipe galleries. The outstanding achievements of its application include:

(1) Collision check

Through the integration and collision inspection of the full-professional BIM model, a full-professional and professional collision inspection report is formed. The report is passed on to the construction unit and the whole-process engineering consulting unit for review through the collaborative management module in the platform, and the relevant design units are coordinated to propose solutions. Through the three-dimensional visualization of BIM, the errors and omissions in the design drawings are reduced, and the overall drawing quality is improved. The focus of collision inspection is on professional crossovers and complex pipeline areas, such as the intersection of baggage handling area baggage system with electromechanical and structural issues, and the intersection of rainwater outlet pipe with civil defence structure.

The collision inspection of the baggage system is the focus of the collision inspection application in the terminal building. There are many baggage conveying equipment in the baggage handling area, and the electromechanical pipelines above are dense, which is prone to collision problems. Based on the BIM model in the design stage, the relationship between the baggage system and the electromechanical pipelines in this area is sorted out and analyzed with emphasis.

Simulation of traffic flow in the landside transportation system

The Jinan Phase II high-speed railway intercity railway, urban rail transit, expressway, and urban road seamlessly connect, and passengers can arrive at T2 by various modes of transportation such as private cars, online car-hailing services, long-distance buses, airport buses, and taxis. By establishing a complete BIM model of T2, the comprehensive transportation center, parking building, municipal roads, and viaducts, the landside traffic flow line can be simulated and demonstrated, allowing for a visual understanding of the spatial relationship between roads, viaducts, and ramps.

(3) Simulation of pedestrian flow in T2 Terminal and the Comprehensive Transportation Center

The Jinan Phase II project has a large scale and complex structure, with a large area and multiple floors in T2 Terminal and the Comprehensive Transportation Center. By utilizing the integrated BIM model, the pedestrian flow analysis is conducted to verify the rationality of the architectural flow line design for different processes such as passenger departure, arrival, and transfer, as well as for the flow lines of passengers. This provides support for design optimization.

(4) Simulation of Non-stop Construction

Non-stop Construction has always been a challenging aspect in the airport reconstruction. BIM application for non-stop construction has certain requirements for the construction unit and participating organizations. In terms of personnel, site management personnel should grasp the construction progress and conduct BIM organization and management based on actual conditions. Participating organizations need to have BIM implementation personnel with BIM foundation and on-site construction experience. Technically, the construction unit needs to advance reasonable BIM application requirements to participating organizations and organize construction companies to produce BIM simulation animations based on the non-stop construction plan. In terms of organization, on-site personnel from relevant organizations should be organized to learn the simulation animations, which are used to brief the construction personnel through animation and help them understand the construction process and contingency plans for unexpected situations.

(5) Other Application Effectiveness

Due to the extensive and complex baggage system in the Jinan Phase II project, BIM roaming simulations are conducted for various baggage flow lines. Through BIM models and simulation videos, the transmission trajectories of the baggage, as well as the relationships between the baggage system and other professional models such as architectural structures and electromechanical systems, can be more intuitively reflected. This coordination among various specialties optimizes the design scheme and enables more efficient communication with the operations and maintenance department.

BIM technology is used to simulate visual lines for key content and critical areas of the project. It considers the height and range of visual lines for staff and passengers, demonstrating areas of visual obstruction. This aids the construction unit in comparing and optimizing schemes to achieve desired usage effects. For instance, simulations of passengers' visual lines along the lane sides of the terminal can assist in the selection of landscape design schemes through visual simulation analysis. Tower visual simulations can more intuitively reveal visual obstructions.

Through the integration of the overall site and municipal BIM models, as well as the reconstruction of the overall terrain model, a digital terrain model for comprehensive analysis and simulation is formed. This model, along with full-site models and profiles, enables intuitive studies of various site elevations, buried depths of underground pipeline corridors and gravity flow pipe ditches, and gradients. This allows for the identification of unreasonable and potentially risky areas.

It also analyzes the elevation, slope direction, and water catchment conditions of the entire site, verifies the design content such as pipeline layout and soil cover thickness, and displays it in chromatogram form, facilitating design control and addressing design omissions resulting from complex design interfaces.

5. Conclusion

With the deepening of BIM applications, BIM utilization that encompasses the entire lifecycle, is comprehensive, and involves multiple parties for coordination will become an inevitable trend. Taking the expansion and renovation project of Jinan Yaoqiang Airport as an example, this article analyzes the key points and achievements of using BIM technology in airport expansion and renovation projects:

(1) Given the multi-disciplinary complexity of airports, it is necessary to establish a BIM management model led by the construction unit with overall control provided by the BIM technical service unit. Relying on the professionalism of the BIM technical service unit, the overall BIM technical work should be planned and coordinated to deepen BIM applications.

(2) In the preparation stage, it is necessary to establish a unified BIM application standard system for the project to guide and standardize the implementation of BIM by various participating units. A BIM communication and collaboration mechanism should also be established to provide basic conditions for the coordinated work of various specialties and participating parties, improving collaboration efficiency through visualization and digitization methods.

(3) BIM technology can be applied to simulations throughout the engineering process, enabling collision checks, baggage system conflict simulations, traffic flow simulations, and more. In expansion and renovation projects, emphasis should be placed on simulations of construction without flight suspension. Comprehensive BIM applications serve as the digital foundation for building smart airports, providing support for the construction of "four-type airports."

Acknowledgements

The research was supported by the civil aviation safety capacity fund of Civil Aviation Administration of China.

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