



Application of Intelligent Construction and Management Platform for Urban Rail Transit

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Abstract

Relying on the Tianjin Metro Line 10 project, a software system platform has been independently developed to enable parametric collaborative design, construction organization management, intelligent detection, and monitoring throughout the entire construction phase of an urban rail project on a unified platform. Through digital delivery technology, BIM results are stored in geometric and non-geometric information, and then delivered to the operation and maintenance platform for use, finally achieving full professional, full stage, and full project management. In the design stage, multi-level detail expression and parameter inheritance and expansion are realized, and parameter transmission is used to open up the links of scheme design, construction site design, and model application, so as to realize the inter-connection of BIM results at the parameter level. In the realm of construction management, fueled by progress and process information, it is possible to swiftly simulate construction processes for inspection and optimization of the construction organization. This enhances the connection and coordination between processes, ultimately elevating the project quality and safety management level. In terms of delivering results at each stage of the project, the CIM hierarchical system is utilized to express information level by level, starting from the line network level, station level, component level, and equipment management level. This forms a BIM three-dimensional design result delivery system, enabling digital delivery and collaboration through documents and parameters. This approach enhances the level and efficiency of collaboration throughout all project stages. A popularized digital design, construction, operation, and maintenance management scheme and software platform have been developed by the project. It utilizes Building Information Modeling (BIM) as the database and engineering parameters as the collaborative subject. This platform covers all stages of parametric design, intelligent construction, operation, and maintenance. It provides structured data support for the later operation and maintenance of the project, enabling full life-cycle management and control of the project on a unified platform.

Keywords

Urban rail transit, digital construction, management platform, digital delivery

1. Introduction

The digital construction management platform of urban rail transit is based on the Tianjin Metro Line 10 project. Through independent research and development of software system platform, it realizes parameterized collaborative design, construction organization and management, intelligent detection and monitoring and other functions in the whole construction phase of the urban rail project on a unified platform. Through digital delivery technology, BIM results are stored in

geometric and non-geometric information and then delivered to the operation and maintenance platform for use, Finally, the "one map, one integration" management of the whole profession, whole stage, and whole project will be realized [1].

Tianjin Metro Line 10 project is the external filling line of the southeast half ring of Tianjin city, with a total length of 21.18 km and a total investment of about 22 billion yuan. The project is large in size and complex in design and construction process. Relying on the comprehensive R&D capability of the "National Engineering Research Center for Digital Construction and Evaluation Technology of Urban Rail Transit" of our institute, through the independently developed digital construction management platform and BIM Technology in the project, the collaborative forward design and comprehensive application of digital construction management in the whole professional and construction stages are realized by parameter transmission [2].

A set of popular digital design, construction, operation, and maintenance management schemes and software platforms have been developed by the project. Building Information Modeling (BIM) serves as the database, with engineering parameters as the collaborative subject. This system covers all stages of parametric design, intelligent construction, and operation, as well as intelligent maintenance. It provides structured data support for the later operation and maintenance of the project, enabling full life-cycle management and control of the project on a unified platform. At present, the platform system has been successfully extended to Xiong'an, Qingdao, Shenzhen, and other cities, and expanded to the field of intercity railway and high-speed railway, with strong development space.

2. Project Overview

The phase I project of Tianjin Metro Line 10 is the external filling line of the southeast half ring of Tianjin city. The line starts from Liyuantou town in Xiqing District in the West and ends at Taiyangcheng residential area in Hedong District in the north. The line runs through Xiqing District, Hexi District, Hedong District, and Dongli District. The main line is 21.18km long, and the total investment is estimated to be 22.069 billion yuan. Speed target value: 80km/h. The project is large in size and the design and construction process is complex. Our company carried out BIM collaborative design and comprehensive construction application in the whole professional and construction stages of the project, achieving the following research breakthroughs.

2.1 Parametric Conversion

With the design parameters of urban rail engineering as the core, it realizes multi-level detail expression, parameter inheritance, and expansion. It makes use of parameter transmission to open up the links of scheme design, construction site design, and model application, so as to realize the interconnection of BIM results at the parameter level [3].

Build a unified model coding system of design software, visual integration software, and information management software, realize the complete transmission of model coding, attribute, and geometric information, and form an information collaborative operation system of the model at different stages.

Based on the CGCS2000 coordinate system, the seamless transformation between the old and new independent coordinate systems of cities is realized, the projection deformation of lines and models is eliminated, and the management of all projects is realized in one drawing [4].

The parameter-driven rapid modeling technology can quickly form the scheme model, reduce the application cost of BIM, and improve timeliness. An engineering linear reference system based on the three-dimensional centerline of the line is established, and based on this, a modeling software for the rapid assembly of interval tunnels and pipelines is developed, which realizes the accurate positioning and model assembly of ancillary facilities based on the line mileage, and simplifies the modeling and Information Association query methods.

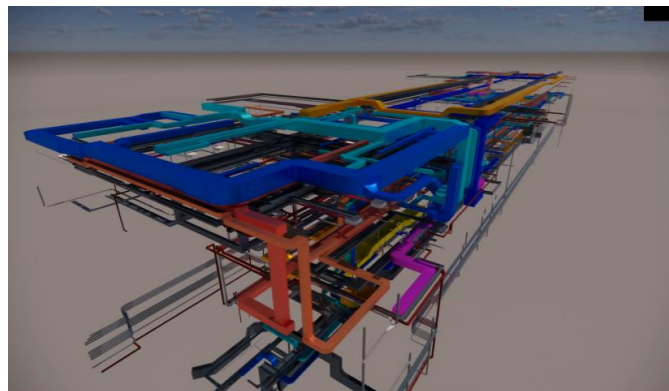


Figure 1. Expression of pipeline comprehensive model.

2.2 BIM Application

It realizes the 4D and 5D information model organization and management of the station foundation pit, main works, and other projects. Driven by the progress and process information, it can quickly simulate the construction process and process, which is used to check and optimize the construction organization, improve the connection and coordination between processes, and improve the project quality and safety management level through the time axis correlation of technical data, on-site monitoring and inspection information [5].

Taking the BIM model as the digital base of the main line of construction progress is the innovation of management means throughout the construction process of urban rail transit projects. With progress as the main line, it has the functions of construction organization plan, log filling, construction progress display, analysis, and early warning. The integrated management of construction schedule data and construction organization plan can dynamically adjust the plan according to the actual progress. The digitalized management of construction information is coupled with the BIM+GIS model to realize multi-dimensional management and control of the project [6].

By associating the urban rail transit engineering data (progress data, cost data, inspection lot, etc.) with the BIM model, the construction management based on the engineering entity is more scientific and standardized; A number of independent functional models, such as survey data management model, construction drawing management model, design change model, construction schedule model and construction log, are established by using the domain driven design concept and method. The functional modules are seamlessly decoupled, and the system has better expansibility.



Figure 2. Construction schedule simulation.

2.3 Application Software Development

It realizes multi-source data integration and information sharing. Relying on BIM+GIS, it seamlessly integrates the data of various stages of survey, design, and construction of urban rail transit stations and areas realizes the integration and sharing of survey and design data, construction drawings, construction organization plans, project progress, construction logs, quality safety and other information, and meets the needs of comprehensive information management in the survey, design and construction stages of urban rail transit. At the same time, it can reflect the construction progress and safety and quality risk control of the project as a whole and the station area at any time, and establish a query platform for all-round information, data, and documents to provide a basis for leaders to make decisions [7].

Developed digital delivery technology. In terms of the delivery of results at various stages of the project, relying on the results of scientific research projects, and applying the digital delivery technology of design results independently developed by our institute, the CIM hierarchical system is used to complete the level-by-level information expression from the line network level, the station level, the component level, and the equipment management level, forming a BIM three-dimensional design result delivery system. The results at the stages of engineering design, construction, operation, and maintenance are delivered and coordinated digitally at the level of documents and parameters, improving the coordination level and efficiency of the achievements in various stages of the project [8].

2.4 Analysis and Import of Passenger Flow Simulation Data

The system has developed the passenger flow simulation analysis data and import module. Combined with the actual situation of the station passenger flow, the system has analyzed various factors affecting the passenger flow line, providing a basis for selecting relevant data that can truly reflect the station passenger flow line, and further improving the model for simulation [9].

Personnel attributes in the evacuation model include personnel type, personnel composition distribution, and personnel walking speed. The personnel classification and composition ratio are set as men (50%) and women (50%). The walking speed of personnel types refers to the suggestions of the SFPE Handbook in the United States and is reduced to a certain extent in combination with the statistical data of personnel size and walking speed in China.

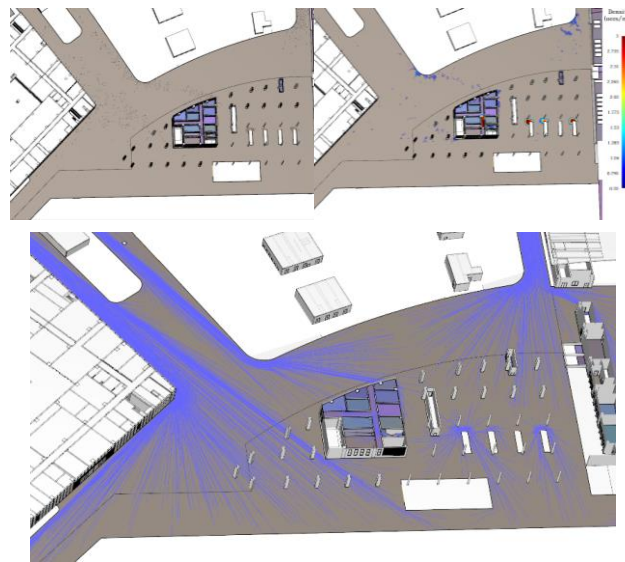


Figure 3. Comparison Chart of Passenger Flow Visualization Data.

Table 1. Parameter setting of crowd

Table Head	Parameter Setting of Crowd		
	Type of residents	Travel speed	Model width
1	Adult	1.3~1.4	0.4~0.5
2	Children	0.6~0.7	0.3~0.4
3	Aged	0.5~0.8	0.4~0.5

Based on the relevant parameters of buildings and personnel debugged during scene model simulation, conduct predictive simulation on the research site. Through the simulation of passenger flow in working days and holidays in the main passenger flow intensive areas in the scene, under the existing scene facilities, the bus stops and passenger stations represent the service level of C~D, and the basement represents the service level of B~C, which can meet the needs of station distribution. Transform the traditional static and qualitative analysis into a dynamic, qualitative, and quantitative combination, and conduct an intuitive and accurate analysis of various spaces in the transport hub, providing a strong guarantee for the planning, design, and operation of the transport hub.

3. Software Application

Independently developed digital construction management platform. Integrated application of collaborative design and construction management is carried out in the whole professional and construction phases of the project in combination with BIM Technology. Through the independently developed BIM+GIS construction management platform, parametric forward design, construction organization management, on-site detection and monitoring, construction planning, log filling, construction progress display, analysis and early warning, multi-dimensional control and software integration are realized in the whole construction phase of urban rail project on a unified platform. It can also deliver BIM results to the operation and maintenance platform through digital handover and open data interface, and finally realize the "one picture" management of the whole profession, the whole stage, and the whole project.

Automatically generate the 3D line centerline according to the plane and vertical sections of the line, and use the parametric segment family and system component family to complete the Complete shield interval model creation including the automatic layout of components of the segment layout system.

Skyline and other GIS platforms and independently developed modules. Based on BIM+GIS technology, the 4D and 5D information model organization and management of the station foundation pit, main works, and other projects are realized. Driven by progress and process information, the construction process and process are quickly simulated to check and optimize the construction organization, improve the connection and coordination between processes, and improve the project quality and safety management level through time axis correlation of technical data, on-site monitoring, and inspection information [10].

In the design stage, in-depth combination with the current national standard-green building evaluation standard, BIM Technology is used to simulate the index items in the standard, and the simulation results are fed back to the construction management system through the developed platform, so as to automatically modify the design parameters, realize the pre-evaluation of the overall project scheme, and improve the quality and efficiency of scheme optimization.

Complete the creation of BIM models with accuracy no less than LOD4.0, including BIM models of complex nodes, complex shapes, traffic dispersion, etc. Using AR and VR technologies, combined with model rendering software, the design effect can be presented in multiple dimensions.

During the project's operation and maintenance stage, an intelligent operation and maintenance platform is developed. This platform utilizes the BIM model as the digital foundation, integrating CIM, Internet of Things, big data, and cloud computing technologies. It manages structured and parametric data from the design and construction stages to establish an intelligent operation and maintenance system for the project. This system enables intelligent station control driven by the BIM model.

4. Conclusion

Tianjin Metro Line 10 project is the external filling line of the southeast half ring of Tianjin city, with a total length of 21.18 km and a total investment of about 22 billion yuan. The project is large in size and complex in design and construction process. In the north extension of the project, BIM Technology is combined to comprehensively apply parametric collaborative design and digital construction management in the whole professional and construction stages. Through the independently developed BIM+GIS construction management platform, the functions of parametric collaborative design, construction organization management, intelligent detection, and monitoring in the whole construction stage of an urban rail project are realized on a unified platform. In combination with the BIM standard of the alliance. Through digital delivery technology, BIM results are stored in the form of geometric and non-geometric information and then delivered to the operation and maintenance platform for use. Finally, the "one map, one integration" management of the whole profession, the whole stage, and the whole project are realized.

Relying on the BIM application process and experience of the Tianjin Metro Line 10 project, a set of popularized digital design, construction, operation, and maintenance management schemes and software platforms have been developed, which take BIM as the database and engineering parameters as the collaborative subject, covering the whole stages of parametric design, intelligent construction and construction, intelligent operation and maintenance, providing structured data support for the later operation and maintenance of the project, and realizing the full life cycle control of the project on a unified platform. At present, the platform system has been successfully extended to Xiong'an, Qingdao, Shenzhen, and other cities, and expanded to the field of intercity railway and high-speed railway, with strong development space.

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