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APPLICATIONS OF BIM TECHNOLOGY TO SUBWAY STATION CONSTRUCTION MANAGEMENT PAPER

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ABSTRACT
The subway station construction conditions of the Shijiazhuang Shiguang Street Station are seriously limited. The underground pipelines of various types are complexly interwoven, making construction difficult and raising the requirement of construction management. Due to a large number of important surrounding buildings, subsidence monitoring should be strengthened so as to ensure construction safety. To the end, this paper uses the BIM technology to develop the subway three-dimensional model, deformed component model, detail loft model to realize three-dimensional disclosure, quantities of work withdrawal, construction procedure optimization, guidance for construction loft, simulation during the construction process, 4D construction dynamic management, and 4D dynamic subsidence monitoring. The practical application effects will be more satisfactory.

INTRODUCTION
With promotion of national digitalization, informationalization and innovation-driven strategic development plan in China, BIM known as an important means of informationalization in the architectural industry has found wide applications in enterprises and public institutions. So far, BIM technology has achieved remarkable application effects in China's architectural engineering field, and its value has gained recognition of the whole industry. As China's urbanization accelerates, urban transportation particularly urban underground traffic has become increasingly important. In China, application of BIM technology to China's subway construction and design started late, and the application value in engineering practice is calling for further exploration.

PROJECT OVERVIEW
Shijiazhuang Shiguang Street Subway Station features an underground two-floor dual-span framework structure. The open-cutting top-down construction method is adopted. The average floor elevation within the station construction area is 79.23m. The station structural overlay thickness is 3.9m on average. The upper part of the station's main body envelop enclosure adopts concrete retaining wall, while the lower part features "cast-in-situ pile+steel shortcrete." The cast-in-situ pile is Φ800×1,200, and constitutes part of the subject structure's side wall. Together with the lining wall, a composite structure is formed. The cast-in-situ pile depth can be divided into three types. There are 286 A-type piles with a depth of 20.54m; there are 50 B-type piles with a depth of 22.98m; there are 50 C-type piles with a depth of 23.12m. The material features C30 underwater concrete. Between the piles, the suspended net shotcrete with an average thickness of 80mm are adopted. The envelop enclosure is supported by three Φ609×12 and Φ609×16 steel pipe support. The third support of the steel pipe employs upside down construction.

3 BIM three-dimensional modeling of the subway station

The subway station is a transfer stop. The subway station has a complex spatial structure and multiple underground floors. The modeling scope includes structures related to the subway station underground excavation process, such as excavation shaft, cross aisle, small guide holes, and other items of the subway station architectural system. Meanwhile, it covers walls, beams, columns, and rebar models constituting the subject structure of the subway station. All this poses a heavy modeling burden on the construction team. Therefore, it is of vital importance to study parametric quick modeling skills, modeling procedures and overall modeling concepts. The modeling process of this project has the following characteristics:

1）Parameterization: In terms of models with a relatively complete structure and a strong distribution rule, the parameter-driven automatic modeling method is preferable;

2）Batched operation: Apply the design model to the construction process. Unify the attribute setting. Quickly and accurately build the BIM model in accordance with the two-dimensional construction drawing paper to realize batched operation of component models. Compile the corresponding modeling and drawing guide for the subway underground excavation station. Standardize the name and pattern of the model. Support the multiperson cooperation modeling and data management.

4 Development and application of the subway BIM 4D management system platform

On the basis of precisely building the subway station BIM model and to better manage and control the subway station construction process, the 4D management system platform is developed and used to analyze the 4D dynamic simulated construction process, WBS filtering technology, process analysis control, preposition task analysis, task lag analysis, 4D resource management, and subsidence real-time monitoring. Meanwhile, the subway engineering production and practice are combined to study the value of the BIM technology.

1） 4D DYNAMIC SIMULATED CONSTRUCTION PROCESS

The 4D dynamic simulated process of general BIM application research projects can be realized via Revit's downstream management software, Naviswork, but the dynamic display effects of Naviswork are unsatisfactory. The frame flash impairs the image definition, which is even more serious when the BIM is large and there are many components. The subway BIM 4D management system platform realizes the 4D dynamic simulated construction process via the following five steps, which can achieve favourable construction effects, strong stability, clear dynamically displayed images, and clear and quick operations:

Step 1: Convert the BIM built by Revit and 3Dmax collectively into the IFC standard format;

Step 2: Import BIMs in the IFC format into the 4D construction management system;

Step 3: Combine the practical engineering status of the subway station and adopt Microsoft Project 2010 to compile the construction schedule;

Step 4: Import the construction schedule compiled by Microsoft 2010 into the 4D management system;

Step 5: Connect the construction schedule compiled by Microsoft Project 2010 with the corresponding model components to realize the construction schedule dynamic driving model.

Through the 4D dynamic simulation, the decision-maker can preview the construction process for the convenience of fully grasping the construction schedule. At the same time, the quantities of work for various time nodes and the reasonability of the space working face can be analyzed in advance to promote the Project Department to optimize construction management and avoid the conflict between staff, materials, machines and space working face.

2） WBS FILTERING

WBS (Work Breakdown Structure) means decomposition of deliverable outcomes and project tasks into smaller parts which are easier for management. “W” stands for formation of tangible tasks; “B” for a gradually decomposed and classified layered structure; “S” for organization of different parts in accordance with certain model. An essential requirement of BIM's WBS filtering is to build a fragmented BIM consistent with the objective construction process in the early period of modeling. This is the so-called BIM under construction. During the use process, the WBS display details can be controlled according to different conditions and better demonstrated to users. The 4D management platform can be reflected through four layers, including procedures, construction sections, items and key paths. At the same time, the system can directly show the construction process through animation or dynamically. Different colors are used to denote different procedures. The project completion status and the project ongoing status are both listed hereunder.

3）SCHEDULE ANALYSIS AND CONTROL

In terms of schedule analysis and control, it means preliminary control of the key construction time nodes and compilation of the schedule based on the target construction period. Following that, the construction schedule can be input into the 4D management system and achieve correlation with the corresponding model. With progress of the project, the practical construction period and the specific time of various procedures are entered into the system. The planned starting time and the actual starting time can be comparatively analyzed. The 4D schedule management system can generate the pie chart according to “statistics by the starting time” and “statistics by the completion time,” respectively. Different colors are adopted to denote the percentage of different schedule statuses to realize schedule analysis and control of every project and even the specific procedure. The progress of the project can be macroscopically viewed by the schedule analysis so that the project’s decision-maker can directly and vividly grasp the whole project progress and realize efficient control of the project schedule by adjusting distribution of staff, materials and machines based on the specific conditions.

4） PREPOSITION TASK ANALYSIS

Preposition task analysis refers to arbitrary check of the completion information of all preposition construction tasks through the 4D schedule management system. Meanwhile, the preposition tasks can be directly export to the Excel sheets for further analysis and contribute to mutual exchange and cooperation between multiple units to prevent occurrence of reworking and slow work.

5. TASK LAG ANALYSIS

There are many factors which result in lag of the subway construction schedule, including barriers of demolition, casualties on the construction site, breakdowns of major machinery equipment, untimely material supply, inference of the surrounding citizens, traffic congestions, etc. After a task is delayed, the 4D system can be automatically used to analyze influence on the follow-up tasks. On the basis, the manager can control the schedule of key construction nodes in a more targeted way and ensure the construction period.

6. 4D RESOURCE MANAGEMENT

The 4D resource management system platform includes the following function models, namely the quantities of work calculation, resource consumption calculation, resource sharing setting, resource sharing calculation, list checking, WBS quantities of work checking, WBS staff, material and machine consumption amount checking, WBS cost checking, component quantities of work checking, component staff-material-machine consumption amount checking, component cost checking, etc. In particular, the WBS quantities of work checking can allow one to check almost every piece of WBS quantities of work statistical information of the whole subway project. The WBS engineering material quantity can be checked on a daily, weekly, monthly or quarterly basis. At the same time, the statistical objects can be checked by their volume, length, area, weight or other parameters.

7. SUBSIDENCE REAL-TIME MONITORING

In order to ensure construction safety of the subway station, the Project Department conducts real-time monitoring of subsidence, and connect observation data with BIM. 526 observation points are set up on the whole subway station construction site and major surrounding spots. The monitoring data are collected on a daily basis. The customized subsidence monitoring function can import the subsidence observation points and daily monitoring data into the 4D-BIM system so that the daily subsidence and overall subsidence can be automatically analyzed and that subsidence monitoring and prewarning can be realized according to different control principles.

8. CONCLUSIONS

The BIM technology has found satisfactory applications in Beijing’s subway stations. Based on the above analysis and discussion, the following conclusions can be drawn:

1) Build the BIM model for the shaft, cross aisle, small guide hole and subway's principal part. Take simulation and management needs during the construction process into consideration. Conduct division and processing of the model;
2) Integrate BIM and schedule into the 4D-BIM system. Realize simulation of the subway underground excavation complex construction process. Realize fine construction management of the construction schedule and quantities of work;
3) Optimize construction procedures. Make use of 4D simulation to demonstrate the construction process. Observe conflicts and optimizable parts of construction procedures in advance for the convenience of reasonable arrangement of construction;
4) Conduct 3D visible disclosure of complex structures. Prevent occurrence of construction mistakes and reworking due to construction staff's misunderstanding of disclosure;
5) Favourable risk monitoring effects: The underground excavation passes through many municipal administration pipelines, thus involving a high construction risk. Combination between the 3D model and the 4D-BIM system can quickly handle the monitoring data, directly observe the position of risks and efficiently control risks;
6) Automatically extract quantities of work: The 4D-BIM system can directly generate the accomplished quantities of work and the planned quantities of work according to the chosen time nodes, thus providing accurate data for project cost analysis and material procurement planning, and avoiding influence of material supply on construction.

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