# 3D Model of A Retaining Structure and A Construction Schedule Based on BIM

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**Keywords:** Retaining Structure BIM Technology 3D Model Construction Schedule

**Abstract.** The popularization of subway systems in large and medium-sized cities in China has increased the requirements for the quality and schedule of subway tunnels and stations. The construction of a subway station is a complicated process that considers cost, schedule, quality, and safety. Revit software was used to establish a 3D visualization model of the retaining structure of a subway station, while the subway station in Navisworks software into the retaining structure of the 3D model, and the TimeLiner module in the software simulation of the construction schedule and its plan. The simulated construction schedule was compared with the actual construction schedule, and result served as a guide for constructing the retaining structure.

## Introduction

Since the 21st century, the rapid economic development in China has led to the popularization of subway systems in large and medium-sized cities to alleviate traffic pressure in these cities. Underground rail construction has commenced simultaneously. The demands for rail transportation construction schedule and construction quality requirements are becoming increasingly high. Under the conditions of considerable demands, difficult construction, and tight construction schedule, ensuring the completion of an underground project within the required construction period and cost is an urgent problem that needs to be solved.

## Application status of building information modeling (BIM) technology

BIM integrates various stages of the entire life cycle of construction project information and system information model for construction projects to provide a convenient database for engineering design, construction, and maintenance management. BIM technology has been widely used in various construction projects in China and has been rapidly promoted in such construction projects.

**Application status of BIM technology in foreign countries.** BIM has been used introduced early and has developed efficiently in many countries. In the construction industry of the United States, over half of the BIM mechanism is used for construction. The application to major contractors is also common in developed countries, such as Germany, Finland, and France. BIM is widely used in all types of engineering, and BIM technology has developed worldwide. The Center for Integrated Facility Engineering of Stanford University has analyzed and studied 32 engineering projects using BIM and summed up a series of advantages of applying BIM technology [1]. The application of BIM technology in Japan has also been extended to the entire country, and many provinces have announced the implementation of BIM in engineering [2]. Many government agencies in developed countries have established standards for BIM application [3].

**Application status of BIM technology in China.** BIM technology has started late in China, but it is developing rapidly in a number of large projects. BIM technology was used in the design and construction phases of the Shanghai World Financial Center, the South-to-North Water Diversion Project, the Beijing National Aquatics Center, and other large-scale projects; the Harbin West Station East Square also applied BIM technology to guide its construction; the China Hydro Mid-South Design and Research Institute was also designed using BIM technology, which significantly saved

design time and cost [4]. BIM consulting companies and various types of BIM training institutions in China have successfully held major forums and seminars, and the government and various industries have paid considerable attention to the application of BIM technology to engineering [5]. The application of BIM technology has gradually become the mainstream in the construction industry; however, the importance and the correct understanding of BIM of enterprises cannot be disregarded.

**Application status of BIM technology in underground engineering.** The development of underground space in China has led to the considerable attention drawn toward the control of cost, the preciseness of design, the safety and progress of construction, and the efficient operation of an underground space. The application of BIM technology to underground engineering—from design to construction, operation, and maintenance management—is an inevitable direction of development with an increasingly fierce competition among various industries [6]. With regard to the application of subway engineering, the Hong Kong Mass Transit Railway has completed one-third of the modeling of all Hong Kong subway stations, and part of the station has underwent in-depth applications of collision detection and operation stage management via BIM, with good application effects. Beijing, Shanghai, and other large and medium-sized cities have also built subway projects, which have been completed using BIM technology [7]. In the present study, Revit software is used to simulate the excavation of a subway station and the excavation process of a subway tunnel as a guide in constructing a subway station.

## 3D visualization model of a metro station based on BIM technology

The studied subway station is a three-story underground station. The platform is 14 m wide, and the total length is 167.60 m. The platform center is YDK16+519.000, and the designed end distance is YDK16+440.100 to YDK16+607.700. The main body of the station is a reinforced concrete rectangular structure. The thickness of the overlying soil is 1.4 m to 3.0 m, the maximum excavation depth of the main foundation pit is approximately 25.34 m, and the safety level of the foundation pit supporting work is grade one. Drilling shows that the measured area of the overlying soil from top to bottom is the fourth artificial soil layer and the transitional layer, which comprise eluvial deposits, weathered rocks, rocks with a strong weathering zone, rock weathering zone, and rock weathered zone. The groundwater in the survey area is divided into two types: pore water and bedrock fissure water in the Quaternary loose layer. Site survey shows no occurrence of landslide, rock collapse, and other geological disasters.

The total length of the foundation pit of the metro station is 167.60 m, the maximum excavation depth is approximately 25.34 m, and the safety level of the foundation pit is grade one. The main excavation station has a retaining wall internal support system, i.e., a three-layer underground excavation with a continuous wall with a thickness of 1000 mm, a two-sided foundation pit support with an underground continuous wall with a thickness of 1000 (800) mm, and one-layer and two-layer foundation pit walls that support the continuous wall with a thickness of 800 mm. The other track section of lateral earth pressure of the foundation pit wall sets a prestressed anchor to offset the track panel wall by using the phase structure. The base pit from top to bottom is provided with four supports. The first three supports are 800 mm × 800 mm, 800 mm × 1000 mm, and 1000 mm × 1200 mm, respectively, with a horizontal spacing of 9 m. The fourth support has a Phi 600 t=16 mm pipe support, a prestressing of 500 KN, and a horizontal spacing of 3 m. Diagonal braces are used in the concrete support section, and their sizes are 800 mm × 800 mm, 800 mm × 1000 mm, 1000 mm × 1200 mm, and 800 mm × 1000 mm.

**3D model of the subway station enclosure structure based on Revit software**. A 3D model of the subway station excavation is established using Revit software. Revit software was especially designed by the Autodesk Company for use in BIM. This software mainly deals with the 3D modeling of industrial and civil buildings, including architectural, structural, and electromechanical models. Revit software is a statistical information platform for building models, and it integrates architecture, geometry, structure, pipeline, decoration, building cost, and all relevant information into the

construction process. Construction personnel can provide concerned parties with the information required to achieve a convenient and collaborative pipe in the construction process. Revit software can be combined with other large-scale finite element software to better analyze the force of the underground structure model. A 3D model of a subway station enclosure built using Revit software is presented in Fig. 1.

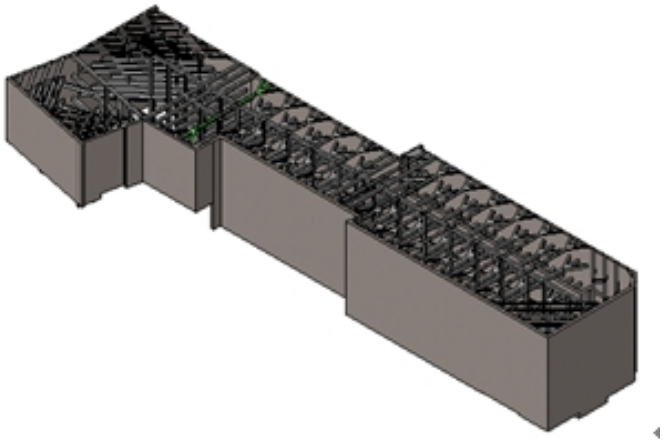

Fig. 1: 3D model of a retaining structure in a subway station.

**4D simulation of the construction process of the enclosure structure.** Navisworks software is used to link a 3D model of the subway station enclosure structure, simulate the construction process of this structure, and guide in the actual construction of this structure.

Navisworks software is a product of the Autodesk Company, and it has seven modules. We can design the construction stage of a 3D model and then convert it into a 4D model. The modules enable Revit to work together, and Navisworks has the following functions: collision detection, real-time roaming, 4D virtual construction, and construction schedule management and rendering. For an architectural information model, Navisworks can provide extensive functions and is widely used in BIM technology. Navisworks software has animation and rendering functions and is perfect for 4D simulation. The design unit can effectively display the design concept and construction process of a simulation project, which can enhance the understanding of a project design and offer certain predictability; the software also has a review tool and can set the function for real-time roaming [8], which can significantly improve the efficiency of the synergy among the members of a project team.

The 4D virtual construction technology based on BIM is completed in the design phase. The 3D architecture information model is appended to the temporal dimension to constitute the 4D simulation movement drawing, by building a model on a computer and by means of a variety of visual devices. The main purpose is to follow the construction of the project. The plan simulates the actual construction process and finds the construction process in a virtual environment. Even if a design alteration has been occurred, It can also synchronize the schedule automatically quickly.

The construction process of a subway station requires a reasonable division of labor and coordinated operation among various departments. Therefore, construction schedule management is important in construction process control. The commonly used schedule management software displays the construction progress in the form of text, transverse, or network plan and does not achieve the visualization of the construction process. In Navisworks software, a 3D model is used through the TimeLiner module to link the progress of the building information model and the construction steps associated with the starting and ending times of the construction process. Thus, the construction process and progress can be expressed in 4D form when the schedule in the construction of a modified building information model is automatically updated. A model can be used to connect multiple construction schedules, and the 4D model is adopted to make a visual comparison of different schedules for selecting the most reasonable construction plan.

**Optimization of schedule control by BIM-4D Technology.** *T*he BIM-4D schedule construction model *was* established *a*ccording to this project. *The* material information of various components and various *resources were contained in the 4D model.* Before construction, visual simulation is done by *Navisworks. O*rganization and arrangement of construction, supply of materials, relation of funds *c*ommunication and coordination should be made ahead of schedule. *In order to avoid the loss brought by the* construction schedule delay *and* uncoordinated supply, the time dimension *was added to* the BIM model. In the construction simulation stage, the accuracy and the optimization schedule of the project schedule are reasonably analyzed according to the utilization of the resources and the time limit of the project.

## CONCLUSION

BIM technology has been rapidly promoted in underground engineering. Experience proves that BIM technology can save project cost, provide technical support for construction management and post-operation, and can be applied to engineering and maintenance. The BIM core software, Revit, is used to establish a 3D model of the retaining structure of a subway station based on Navisworks. The maintenance construction plan of the subway station is simulated using the TimeLiner module in Navisworks. The actual and simulated construction schedules are compared, and the following conclusions are drawn. The integration of BIM technology into underground engineering will be extensive with the development of various high-end information technologies and will create significant values for the society and for engineering enterprises.

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