BIM Application and Practice in Substation Construction Management

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Abstract

Substations are an important component of power grid projects and have a substantial impact on public livelihood and production. Although the building structure of substations themselves is relatively simple and regular, there is a wide variety of associated equipment, the line layout is relatively complex, and the construction difficulty is substantial. During the construction process, issues such as inadequate planning, on-site rework and waste, and schedule delays are inevitable. The application of Building Information Modeling (BIM) technology in construction management is one approach to addressing these problems. This paper presents relevant practical work using the Taizhou Wendong Gaoshan 220KV substation project as a case study.

Full Text

BIM Application and Practice in Substation Construction Management

—A Case Study of Taizhou Wendong Gaoshan 220 kV Substation

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Abstract Substations are an important component of power-grid projects and have a major impact on people' s livelihoods and production. Although the buildings and structures of substations themselves are relatively simple and regular, the related equipment is numerous and varied, the line arrangement is relatively complex, and construction is also relatively difficult. During project construction, problems such as incomplete consideration, waste caused by site rework, and schedule delays are therefore liable to occur. The application of building information modeling technology in engineering construction management is one of the ways to solve the above problems. Taking the Taizhou Wendong Gaoshan 220 kV substation project as an example, this paper carries out relevant practical work.

Keywords BIM; construction management; substation

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Project renderings

Figure 1: Project renderings

Introduction

In recent years, building information modeling (BIM) has become widespread and developed rapidly in China' s engineering construction industry, and there have been many successful application cases in numerous large-scale domestic engineering projects. However, its application in industrial building projects such as substations is still at an initial stage. Substations are an important component of the power-grid system and have a major impact on people' s livelihoods and production. Although the buildings and structures of substations are relatively simple, the related equipment is numerous and varied, the line arrangement is relatively complex, and construction on site is also relatively difficult. Therefore, during project construction, problems such as incomplete consideration, waste caused by site rework, and schedule delays are liable to occur. The application of building information modeling technology in engineering construction management is one of the technical approaches for solving the above problems.

1 Project Background

The Taizhou Wendong Gaoshan 220 kV substation project is located in Taizhou, Jiangsu. The associated lines are located within the jurisdictions of Jingjiang City and Taixing City. The project comprises two buildings: a 220 kV GIS production complex and a 110 kV GIS production complex. The site area is 1,722 m^2, the total building area is 4,364 m^2, the building height is 18.3 m, and the designed service life is 50 years. Among them, the 220 kV distribution equipment is arranged on the second floor of the building on the north side of the site and uses indoor GIS equipment; the 110 kV distribution equipment is arranged on the third floor of the building on the south side and uses indoor GIS equipment. The main transformer is arranged outdoors between the north and south electrical buildings. A transportation road is laid between the electrical building on the north side and the main transformer yard and is connected with the access road. The substation gate is located on the north side of the site, and the access road leads from a high-grade road along the Yangtze River on the north side of the station area.

Figure 1 Project renderings

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···connection. Ring roads are provided within the station to facilitate the trans-

port of large components and to meet the requirements of fire inspection and repair.

2 Construction Management Method for Substation Projects Based on BIM

Substations undertake important tasks in the power system. Unlike ordinary civil buildings, the design and construction of such projects are specialized industrial construction; the site grading workload is large, excavation and backfill quantities are seriously unbalanced, there are many on-site devices and ancillary buildings, and the requirements for construction process quality are also high. The application of BIM technology can effectively improve the efficiency of project construction management and is conducive to achieving refined construction management. The BIM digital model contains digital information for all types of equipment and pipelines in the substation, and can store information throughout the entire process from design and construction to operation and maintenance, and even to the end of the substation life cycle. It can provide the project' s specification parameters, progress, and cost information in real time.

The construction management of this substation project based on BIM is divided into two stages:

First is the construction preparation stage. A three-dimensional BIM model of the substation is established, and the visualization features of BIM are used to check the design results of the various disciplines—architecture, structure, electrical, water supply and drainage, HVAC, and cable routing—so as to identify and resolve relevant engineering issues in advance before construction. In addition, BIM can be used to simulate the construction scheme and to deduce and optimize the construction processes, procedures, labor, materials, and other aspects.

Second is the construction implementation stage. On the basis of the construction operation model completed in the construction preparation stage, construction site management is carried out based on the BIM model. Usually, the engineering operations are linked with the model, and management work is carried out around progress, quality, and safety, assisting in the resolution of engineering problems.

3 Specific BIM Application Content

3.1 Construction Preparation Stage

The main work in the construction preparation stage is to establish the necessary technical and material conditions for project construction, coordinate and arrange construction forces and the construction site, and enable the project to possess the basic conditions for commencement and construction. Construction

Project BIM model

Figure 2: Project BIM model

Verifying construction feasibility through the model

Figure 3: Verifying construction feasibility through the model

preparation is an important guarantee for the smooth progress of building engineering construction. The application value of BIM in the construction preparation stage is mainly reflected in construction detailing and construction-scheme simulation.

(1) Construction-scheme detailing

The main purpose of construction detailing is to improve the accuracy and verifiability of the detailed building information model. Construction operation specifications and construction processes are incorporated into the construction-operation model so that the construction drawings meet the needs of construction operations.

The construction detailing of this project is divided into three steps. First, the design results are visually expressed through BIM. With the aid of BIM' s three-dimensional visualization features, construction handover can be better achieved, making it easier for construction management personnel to understand the design intent.

Second, the constructability of the design results is analyzed. Through BIM' s three-dimensional collision-detection function, models of each discipline are checked separately and the integrated comprehensive model is also checked. At this stage, the reserved holes and openings in the civil engineering works can also be checked in advance to improve the accuracy of reserved holes and openings. The design results for equipment and cable routes are verified through the three-dimensional model, and the most reasonable construction scheme is identified.

Figure 2 Project BIM Model

Figure 3 Verifying Construction Feasibility Through the Model

Figure 4 Site Layout Model

Figure 5 Construction Scheme Simulation

Figure 6 Comparison of Construction Progress

Finally, the contents of the detailed engineering construction design are compiled

Figure 4. Site layout model

Figure 4: Figure 4. Site layout model

Figure 5. Construction scheme simulation

Figure 5: Figure 5. Construction scheme simulation

Figure 6. Comparison of construction progress

Figure 6: Figure 6. Comparison of construction progress

into detailed technical drawings, and the problems encountered are simultaneously reported to the design unit for feedback and confirmation.

(2) Construction scheme simulation

Construction scheme simulation has two main applications in substation projects. First is site layout planning: BIM is used to carry out comprehensive planar planning. By using BIM to simulate site conditions at different construction stages—including large machinery, material stockyards, processing workshops, safety facilities, and so on—the schemes for each stage are repeatedly deliberated, so that the planar planning becomes more reasonable and implementation becomes more operable.

Second is construction scheme simulation. On the basis of the construction model, information such as the construction process and construction sequence is added to conduct visual simulation of the construction process. The building information model is fully used to analyze and optimize the scheme, improve the accuracy of scheme review, and achieve visualized presentation of the construction scheme.

3.2 Construction Implementation Stage

Construction-site management based on BIM technology is generally carried out on the basis of the construction-operation model completed during the construction preparation stage, together with appropriately selected construction management software. This is not only a visual medium, but also enables optimization and control of the entire construction process. In this way, potential problems in the engineering project can be discovered and solved in advance, reducing uncertainties and risks during construction. At the same time, by simulating the construction process according to the construction sequence and workflow, the schedule can be accurately calculated, planned, and controlled; construction resources such as labor, machinery, materials, and methods can also be coordinately scheduled and optimally allocated, realizing interactive visualization and information-based management of the engineering construction process.

(1) Comparison between virtual progress and actual progress

The comparison between virtual progress and actual progress based on BIM technology mainly

Figure 7. Quantity calculation

Figure 7: Figure 7. Quantity calculation

Figure 8. BIM quality and safety management

Figure 8: Figure 8. BIM quality and safety management

Figure 7. Quantity Calculation

Figure 8. BIM Quality and Safety Management

The key is to compare the planned progress of the scheme with the actual progress, identify discrepancies, analyze their causes, and thereby achieve reasonable control and optimization of the project schedule.

In this project, BIM was used to assist in the preparation and execution of the schedule plan. The schedule plan and on-site implementation status were deeply linked with the BIM model, so that the comparison between on-site construction conditions and planned progress could be reflected in real time in the BIM model. Deviations in project progress could thus be corrected in a timely manner, effectively ensuring implementation of the project schedule.

(2) Quantity statistics

BIM is characterized by parameterization. The cost-related parameters of the constructed facilities can all be read from the model attributes. Once a design change occurs, this information is automatically refreshed and remains consistent with the design throughout.

In this project, the itemized quantities and project characteristic information obtained from the BIM construction-operation model assisted cost estimators in verifying the preparation of construction cost estimates at each stage, improving work efficiency and accuracy. Through the BIM model, it was not only convenient to calculate material consumption, but also possible to rapidly calculate template quantities, providing good data references for the commercial department. In addition, this project carried out exploratory research on the rational arrangement of masonry infill and on the calculation of reinforcement quantities and rebar detailing, accumulating valuable experience.

(3) Quality and safety management

Quality and safety management based on BIM technology compares on-site construction conditions with the model, thereby improving the efficiency and accuracy of quality inspection and effectively controlling sources of danger, ultimately achieving the goals of controllable project quality and safety. The specific applications in this project were divided into two aspects: quality management and safety management.

In terms of quality management, before project construction began, BIM digital

templates were prepared. These digital templates were of positive significance for technical disclosure and quality control. Management personnel used mobile terminals to input electronic files such as digital templates, CAD drawings, engineering specifications, and forms into tablet computers. On site, they compared the BIM model with the physical works, enabling managers to identify on-site quality problems quickly and intuitively.

In terms of safety management, the model was used to assist in analyzing and eliminating unsafe factors on site, ensuring smooth and safe construction. BIM was used to conduct inspections related to civilized construction, erection of on-site scaffolding, openings, access ways, and protective measures at overhanging locations, thereby safeguarding on-site safety.

4 Conclusion and Outlook

In this project, by establishing a BIM digital model for the substation project, construction-site management was integrated with digital technology, and BIM was applied throughout the entire process of construction preparation and construction implementation. Through practice, a systematic set of working methods was preliminarily summarized, innovation in working methods was achieved, the efficiency of construction management was improved, and technical experience was accumulated for the future realization of refined construction management.

Overall, the application of BIM in substation engineering construction has advantages in three main aspects: (1) Errors and omissions become more controllable, reducing the potential losses from mistakes and rework during the construction stage. By using the model for progress control and repeatedly simulating the construction process through virtual construction technology, problems that may arise during the construction stage can be discovered in advance in the simulation environment, then corrected one by one, thereby optimizing the schedule and construction plan, guiding actual project construction, and reducing problems encountered in construction engineering. (2) Collaboration and communication become smoother. With the aid of BIM, problems arising in the project can be resolved quickly and accurately; by optimizing workflows and changing serial operations into parallel operations, all stakeholders can communicate better through visualization to solve problems. (3) Consideration becomes more comprehensive. By integrating the results of all disciplines through the model, construction management and coordination are facilitated. Before formal construction, managers can predict key points in the project construction process in advance, arrange construction-site layouts and the layout plans for large machinery and measures, and at the same time forecast the funds, materials, and labor required each month and each week. Problems can be identified in advance and optimized, while the technical quality department can use the platform and model to control quality and determine construction plans.

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Application of BIM Technology in Transformer Substation Engineering Construction Management

—Taking Taizhou 220 kV Substation Construction Project as Example

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Abstract: The transformer substation is an important component in the power grid project, which greatly impacts the social people's livelihood and production. The structure of the substation itself is relatively simple and regular, but with various kinds of related equipment and complex circuit layout, the construction of substation also faces some difficulties. Inevitably, there will be some incomplete design considerations, on-site rework wastes, and progress laggings. The application of building information model technology in engineering construction management is one of the approaches to solve the above problems. This paper takes the Wendong high mountain 220KV substation project in Taizhou as an example, to illustrate the relative works with BIM application.

Key Words: BIM; Construction Management; Substation

Note: Figure translations are in progress. See original paper for figures.