Digital Management of Power Transmission and Transformation Works Based on Building Information Model

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Abstract. The application of digital management of power transmission project based on BIM technology is introduced in this paper. In recent years, the vigorous development of China’s power grid, especially the comprehensive construction of UHV power transmission and transformation projects, has provided strong support for China’s power grid construction. With engineering and technical personnel’s gradual dependence on digital information, a 3-D digital management system based on BIM technology has been progressively implemented. It has become an inevitable trend to establish a 3-D digital and integrated platform based on BIM technology to assist owners and operators to jointly manage power transmission and transformation projects. With the wide application of power transmission and transformation entity structure BIM models in the design, construction, procurement, management and operation phases, the advantages of BIM technology in visualization, coordination, simulation and integration continue to emerge in its effective circumventing the risks and hidden dangers of power projects. Thus, BIM technology has gradually become a new channel for enterprises to earn profits and win greater economic benefits and market competitiveness.

1. Introduction

Power transmission and transformation projects include two parts: power transformation works and transmission line works. The technical system of power transmission and transformation digitization project is integrated from collaborative system of multi-dimensional visual design, design data sharing and management system, digital handover system and procurement and asset management system. The technical system will not only realize the professional, mature and joint design of functional software in existing professional fields, including professional applications of electrical engineering, civil engineering, structural engineering, water heating, site, technology and economy, and ensure the sharing and inheritance of design data and multi-disciplinary collaborative design throughout the engineering design, but also pass the data model to the construction, procurement, operation and maintenance and other project phases to contribute to the lifecycle management of power transmission and transformation works [1].
In recent years, the function of BIM technology continues to grow in different areas. How to effectively use advanced concepts of BIM technology to guide the construction of digital transmission and transformation works has become a new hot spot. For example: the completed 500-kV Jing’an (Expo) all-underground substation and 1000-kV Huxi substation which based on BIM 3-D visualization technology model[2], lifecycle management of Tianjin Yongding River 220-kV substation based on BIM technology[3], and construction management of the pre-wiring section of ±1100kV Jiquan line (Ningxia section) [4], etc. With the rapid development of digitalization, networking and large databases, the digital management mode of power transmission and transformation works based on BIM technology will become an irresistible trend and play an important role in multiple phases.

2. Introduction of BIM

BIM (Building Information Modeling) is a digital expression of the physical and functional characteristics of a building, which provides reliable information sharing knowledge resources for the entire life cycle of the building from its completion [5-7]. Through the 3-D architectural model, BIM technology achieves engineering supervision, property management, equipment management, digital processing, engineering management and other functions. BIM technology was invented by Professor Chuck Eastman of Georgia Institute of Technology in the United States and gradually expanded to such developed countries as Europe, Japan and South Korea. China is a late starter in BIM technology. In China, BIM technology first appeared in the Hong Kong and has gradually been promoted in the Architectural Society of China and China Exploration and Design Association. In recent years, China’s BIM has developed rapidly and has been applied in many major projects. It is well known that BIM technology mainly features visualization, coordination, simulation, optimization, and diagrammability. Accordingly, what you see is what you get. 4D simulation, 5D simulation, energy saving simulation, emergency evacuation simulation, sunshine simulation, thermal conduction simulation and parametric information modeling are the most successful applications of BIM technology. In addition, BIM technology can realize integrated management of whole life cycle process, ranging from design to construction, and to operation; modeling and multi-condition analysis of structural ontology through parametric modeling; BIM technology can realize the description of 3D geometric information and topological relations of works, the complete description of project information, etc [8, 9].

Although BIM technology started relatively late in China, it has attracted national and industrial attention. Besides, the relevant laws and regulations and industry standards have been developed quickly. In 2012, four plans of setting BIM Standards was released, which was stipulated by the Ministry of Housing and Urban-Rural Development “2012 revision plan of project construction standard specification” [10]. It marks that BIM standards are formally taken into national science standard system, which will promote the coordinated development of China’s BIM technology, standards, and software, including Delivery Standard of Building Design-Information Modeling, Standard for Classification and Coding of Building Design-Information, Storage Standard of Building Design-Information and Standard for Building Information Modeling in Construction. Among them, Standard for Building Information Modeling in Construction (GB/T51235-2017) was formally put into implementation on January 1, 2018. In recent years, BIM technology has been widely applied in domestic construction projects, including a series of construction projects of complex modeling and spatial relationship, large volumes and high coordination requirements [11], such as Shanghai Tower, Water Cube, Tianjin Port International Cruise Terminal, as well as multiple 220kV, 500 kV, 1100 kV transmission and transformation works.

3. 3-D digital management

The essence of 3-D digital management of power transmission and transformation projects based on BIM technology is to strengthen data interaction during the entire life cycle of power transmission and transformation projects, and quantify management objects and management behaviors through statistical techniques to realize the integrated operation of design, research and development, planning,
organization, production, coordination, sales, service, innovation and other functions. Relying on the concept of BIM technology, 3-D digital management may promote the technical updating of traditional power transmission and transformation projects in various aspects, enabling companies to survive and develop in the constantly changing global market competition and continuously expand their competitive advantages.

3.1. Design phase
Based on such 3-D software as Revit, Bentley and Daoheng, not only 3-D collaborative design (including 3D modeling, collision testing, special load condition check and emergency response preview) of BIM technology can be realized in power transmission and transformation projects, but also project cost management can be used to compare project costs and optimize design, as shown in Fig.1~2. Among them, 3-D modeling refers to building a digital, multi-attribute BIM model based on 3-D platform and provides basis for different professional designers. Soft and hard collisions are key technologies for checking the rationality of the BIM model, including testing the collision of the civil structure of the physical model, the hard collisions of multiple special pipelines, trenches, and wind pipes, as well as such soft collisions as the clearance requirements, the scope of lightning protection, and interval requirements for each electrical component. For the special loads such as strong winds, heavy snowfalls, wind and rain, BIM model was applied to analyze the model through finite element software to provide a corresponding numerical simulation structure for project design. In addition, BIM model can improve the design level of energy-saving simulations, emergency evacuation simulations, sunshine simulations, and thermal energy transfer simulations, thus providing great help for the construction and operation during later phase.

3.2. Construction phase
During the construction phase, the focuses of the project construction are on-site worker safety construction, effective implementation, etc. The application of BIM technology can not only help managers to better control the situation of the substation construction site, ensure the safety of construction personnel, but also increase construction efficiency and reduce construction costs. In recent years, with the continuous development of China’s UHV technology, new technologies have emerged continuously. Therefore, it is necessary to apply BIM technology to the construction process through multiple and multi-planned pre-constructions, and it is also beneficial to construction rationality and safety, as shown in Fig.3~4. Through the computerized comparison of construction plans and the simulation of multiple scenarios, it not only saves construction resources, achieves one-step implementation, avoids secondary rework and delay in construction period, but also can do pre-arranged planning and safeguarding in advance for special situations[10].
3.3. Operation phase

Operation and maintenance phase is the longest and most costly phase of the entire life cycle of a power transmission and transformation project [12]. The digital model based on BIM technology has accumulated rich information through such phases as design, procurement and construction. It is also a data base for all operations, maintenance and management of power transmission and transformation projects. Compared with previous projects, the data model remodeled through BIM technology has significant advantages: it can not only reduce operation and maintenance costs, improve operation and maintenance management, but also create more social and economic benefits, including visualized spatial control, traceability of project maintenance, and safety of on-line monitoring all the time. In addition, operation and maintenance personnel can integrate built drawings, design parameters, historical records, operating years, maintenance records, and other data of BIM model into the existing operation and maintenance management system to continuously track and maintain the electrical equipment, thus maximizing the benefits of power transmission and transformation projects on the basis of ensuring safe and reliable operation.

4. Conclusions

With the development of power grid technology, long-distance and large-capacity power transmission projects, such as UHV AC/DC must be completed by several design units, construction units, and construction management units. The multi-sited collaborative design, construction, management and later operation and maintenance have become the inevitable requirements of digital management of power transmission and transformation projects based on BIM technology. It has become an inevitable trend to establish a 3-D digital integration platform based on BIM technology to help owners and operators manage design, construction, procurement, management and operation in different phases. As BIM technology continuously shows advantages in visualization, coordination, simulation and integration, it can effectively avoid the potential risks of power projects and gradually become a new channel for enterprise profits, and win greater economic benefits and market competitiveness for enterprises.

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