The application of 3D design technology in the design of 220kV substation in Miluo Western

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Abstract. Based on engineering information and geographic information data, through the integrated application of 3D modeling technology and digital collaborative design technology, the 3D visual design and information integration of power transmission and transformation projects are completed. 3D design can realize complex underground pipeline layout, cable optimization layout, collision inspection, visual display, etc. It is helpful to reduce the soft and hard collision of the project, ensure the design safety and quality, optimize the work quantity and guide the construction. In this paper, through the application of 3D design technology in the design of 220kV substation in Miluo Western, the main aspects and benefits of application are summarized, and the existing problems are analyzed for reference in other engineering applications.

1. INTRODUCTION
3D design is a new generation of digital, virtual and intelligent design platform. It is a new generation of design technology which takes 3D space technology as the symbol and digital technology as the link, integrates the design information of various specialties, and comprehensively improves the quality and efficiency of engineering design.[1]

Compared with 2D design, 3D design is characterized by "space" and "digitization". It has one more dimension than 2D design, so it has the concept of "space", which is richer and more realistic than 2D image content and more in line with human visual characteristics. A large amount of data (geometric data, attribute data, etc.), documents, drawings, etc. generated in 3D design can be integrated with each other. Compared with the data display in 2D, it presents a more powerful, easy to manage, calculate and use digital characteristics.[3-5]

2. 3D DESIGN OF SUBSTATION
3D design technology of substation engineering is an integrated innovation of modeling technology, information technology and network technology in the design field, which is conducive to the optimization of design, construction and installation, production and operation and maintenance, and is conducive to improving the intrinsic safety level of power grid engineering throughout the life cycle. It is an important means of building smart grid.

Using the spatial characteristics, the 3D design of substation can realize the complex underground pipeline layout, cable optimization layout, collision inspection, construction simulation, visual display, etc. Using the characteristics of digitization, we can realize the main wiring design (such as extracting the main parameters required by the main wiring from the equipment properties, automatically generating the main wiring parameter table, etc.), electrical calculation (such as lightning protection...
calculation), engineering quantity statistics, material reporting, construction schedule management, operation and maintenance management, digital handover, etc.

### 3.3D Design of Miluo Western 220kV Substation Project

#### 3.1 Project Profile
Miluo Western 220kV substation is located in Shiniu Village Gupei Town, Miluo City of Hunan Province, 6.3km north of Miluo City, 15.8km east of Beijing-Zhuhai Expressway Pingjiang West entrance, 20.8km northwest of Yingkou Town. Both 220kV and 110kV terminal and current phase are connected by double bus. Single bus three-section connection is adopted in the final phase of 10kV, and single bus connection is adopted in the current phase. The main transformer adopts three-phase three-winding on-load voltage regulating oil-immersed self-cooling high impedance transformer, GIS combination electrical appliances are used for 220 and 110kV, and metal-armored indoor switchgear is used for 10kV. The construction scale is shown in Table 1.

#### Tab. 1. The construction scale of Miluixi 220kV substation

| No. | Item                  | Current Period | Terminal |
|-----|-----------------------|----------------|----------|
| 1   | Main Transformer       | 1×180MVA       | 3×180MVA |
| 2   | 220kV Line            | 2 Lines        | 8 Lines  |
| 3   | 110kV Line            | 6 Lines        | 12 Lines |
| 4   | 10kV Line             | 10 Lines       | 24 Lines |
| 5   | Reactive Compensation | 3×10MVar Capacitor | 9×10MVar Capacitor |

This project depends on the outdoor GIS general design scheme of the State Grid Corporation of China. Both 110kV and 220kV GIS equipment adopt the "combined sail type" off-line mode. The whole substation trusses, power distribution building, guard room, main transformer firewall and hydraulic structures are designed and constructed according to the assembly scheme.

The project is the support project of the 2017 3D Design Competition and one of the first 3D design pilot projects of the State Grid Corporation of China. The preliminary design review was completed in April 2018, the official construction started in September, and the construction was officially completed and put into production in June 2019.

#### 3.2 Platform Application
This project is based on the Bentley platform. The main application software includes: collaborative design PW module, electrical and civil engineering modeling modules, real scene modeling, rendering modules, construction and application modules Synchro Pro, etc. Shanghai Xindian software is used for digital design for electrical secondary system.

Bentley platform is a 3D software for substation integrated electrical and civil engineering design. It has the functions of creating bill of materials, performing conflict detection and spacing detection. Its most prominent advantage is the realization of distributed engineering design. Substation design usually involves many different specialties, such as electrical primary, secondary and civil engineering. The modification of the scheme will bring a lot of inter specialty coordination work. Bentley provides good support for project content management and team cooperation through ProjectWise component, and realizes the concept of substation design workflow[^4].

#### 3.3 3D Design
This project is the first batch of substation projects of the State Grid Corporation to carry out the 3D forward design of construction drawings. Through Bentley PW platform, it has realized the collaboration design of electrical primary, secondary, general drawings, architecture, structure, water
supply and drainage, ventilation and air conditioning, and established the electrical main wiring logic model and 3D layout model. The 3D model of this project covers the geographic information of the whole station, gates, roads, cable trenches, power distribution devices, secondary equipment compartments, secondary screen cabinets, whole station structure supports and equipment foundations, 10kV cables, underground pipe networks, HVAC and outlets terminal tower, etc., It is shown in Fig. 1.

3.3.1 Lightning protection design
Based on the 3D design model of this project, analysis and calculations such as 3D electrical safety net distance verification, 3D lightning protection verification (Figure 2), fine cable laying design, intelligent terminal wiring design, mechanical analysis and earthwork balance calculation have been carried out. Integrating the layout model of the whole station, carrying out comprehensive collision inspection, and extracting the plan view and material table through the model.

3.3.2 3D forward data
The 3D model of each specialty carries out forward funding. For example, the main transformer carries out 3D forward data for civil engineering, determines the location of the main transformer foundation and oil pit, and defines the height of the frame and the location of the beam hanging line. In addition to the detailed location of the equipment, the height of the arrester support and the installation details of the head plate are determined simultaneously (Figure 3).

3.3.3 Fine modeling
Electrical primary specialty completes the electrical wiring design and 3D layout design of electrical primary equipment, facilities and materials in the whole station. The logic model of substation main wiring is established, which contains attribute information and coding information, and can realize intelligent linkage navigation with 3D layout model. The model of the whole station grounding facilities, including the main grounding grid, equipment down lead, and the accurate model of the whole station lighting, is refinedly built (Figure 4).
The electrical secondary specialty follows the naming habit of secondary equipment to establish the secondary equipment library, which can automatically associate the 3D physical model and facilitate the import of 3D software for cable laying. The models of secondary panel cabinet and its devices, fire alarm and intelligent auxiliary control are accurately established, and the 3D layout design of secondary equipment room, battery room and wiring channel inside and outside the prefabricated cabin is completed in detail (Figure 5).

Based on the digital elevation model required in the construction drawing design stage, the general layout design of the station area is carried out, and the collision inspection of underground facilities is completed. Carry out the layout design of Road (including access road), site, fence, underground pipe trench, etc. Completing earthwork balance calculation and other vertical layout design.

Architecture and structure specialty have completed the 3D design of the building structure of the power distribution equipment room and guard room, and completed all the detail nodes, including foundation, purlin, canopy, beam column connection nodes (Figure 6).

The 3D design of frame, equipment support, ladder, fence and all equipment foundation is completed. Professional software is used for structural analysis and detailed design of structural support and equipment foundation. For example, the detailed design of 110kV frame has completed all the detailed nodes, including hanging board, ladder cage, railing corridor, beam and column nodes. The assembly model can be completely achieved, and it can be processed directly by parts(Figure 7).

Complete the 3D design of water supply and drainage system, water supply and drainage pipes of main buildings, heating and ventilation, fire protection system of the main transformer and other facilities. The water supply and drainage system of the station area, the water supply and drainage pipes of the main buildings and the fire fighting system of the main transformer contain the pipe diameter, material and other information, and the building HVAC includes the model and power of the air conditioning and fans(Figure 8).

3.3.4 Comprehensive collision inspection
The professional layout models are integrated, a comprehensive collision inspection is carried out to quickly and accurately detect the location and number of collisions (Figure 9).
3.3.5 Quantity statistics
Professionals can extract quantities from 3D design models and complete automatic statistics (Figure 10).

3.3.6 Engineering code
According to the coding rules of main equipment material and grid identification system, the detailed codes of equipment, structures, HVAC, hydraulic engineering, etc. are compiled (Figure 11).

3.3.7 3D drawing output
Based on the 3D design model, major construction drawings and bill of quantities are extracted (Figure 12), and the scope of drawings meets Technical guide for 3D design of power transmission and transformation project Part 1: substation and converter station.
4.3D DESIGN EFFECT

4.1 Improving the quality of engineering design
It is mainly reflected in the following aspects: first, find the weak points in the design and accurately realize the design reinforcement (Figure 13); Second, use visualization technology to improve the level of design refinement; Third, the use of 3D collaborative design technology to improve the efficiency of professional cooperation.

4.2 Realizing precise investment of Engineering
It is mainly reflected in the following aspects: first, accurate statistics of quantities to achieve accurate budget preparation; Second, enhance the depth of design, achieve fine design and save project investment; The third is the use of 3D model for calculation and analysis, the results are more accurate.

For example, compared with the initial design, the accuracy rate of the construction drawing of the pile foundation, structural support and building steel structure of the project is more than 98% (Figure 14)
4.3 Strengthening the intrinsic safety of Engineering
It is mainly reflected in the following aspects: first, comprehensive collision inspection of underground foundation concealed works to reduce design errors, omissions and defects (Figure 15); Second, the calibration of electrical distance and wind deviation is accurate and intuitive to ensure reasonable design margin; Third, the 3D cable laying is intuitive and 3D, reducing construction errors.

![Collision check](image15)

Fig. 15. Collision check

4.4 Improving the management level of engineering construction
It is mainly reflected in the following aspects: first, all parties involved in the construction intuitively grasp the design scheme, assisting 3D means to improve the efficiency of construction management (Figure 16); Second, the material purchase can automatically extract the material list according to the equipment code and characteristic parameters; Third, visually simulate the process of construction, hoisting, transportation and maintenance, optimize the site layout, equipment configuration and scheme organization.

![Auxiliary joint review of construction drawings](image16)

Fig. 16. Auxiliary joint review of construction drawings

4.5 Meet the whole process application of engineering data application
It is mainly reflected in the following aspects: first, the unified data architecture based on GIM standard can realize the data interaction with engineering data center and transportation inspection intelligent control system; Second, after the handover of the inspection, it can meet the needs of editing, modifying and developing the 3D model of the project in the stage of transportation inspection.

5. CONCLUSION
At present, the information level of our society has entered a new height. With the rise and development of BIM 3D design technology, the design industry has entered a new era of personalized customization. BIM technology (Building information Modeling) is a new design mode based on 3D digital technology, which integrates and effectively manages all kinds of relevant information in the whole life cycle of the project.
5.1 From the point of view of the great advantages of 3D design of substation, 3D design is helpful to reduce the collision between soft and hard engineering, ensure the safety and quality of design, optimize the engineering quantity, and guide the construction.

5.2 For the current design workload, limited by software, personnel application proficiency, popularity and other factors, the design workload of the project has increased by more than 50%. With the improvement of follow-up software functions, the improvement of personnel application level and the accumulation of engineering models, the workload will gradually reduce.

5.3 From the perspective of software application and interface, Bentley series products are mainly used in electrical primary and civil engineering of the project. In terms of software interface, staad.pro, a steel structure calculation software, has an interface with ABD, which can realize the intercommunication between calculation model and 3D design model; PKPM is used to complete the building calculation model. According to the calculation results, Bentley modeling software is used to complete the 3D model, and there are information breakpoints.

5.4 From the engineering quantity statistics, the engineering quantity automatic statistics of main electrical equipment, conductors, fittings, cables, grounding flat steel, lamps, structural support steel and concrete are carried out in this project, which ensures the accuracy and improves the design efficiency.

5.5 After the application of 3D design in this project, more than 30 rework points are effectively avoided, about 500,000 yuan of project changes is saved, and about 65 days of design review time is saved. The construction was completed 30 days in advance, and the economic benefit was about 1,500,000 yuan.

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