Study on Three-Dimension Design Management of Power Grid Projects Centered on Quality Improvement

Wang Ning*, Wu Peng, Zhao Bingjun, XING Lin, WANG Suo, Zhang Shuai, Li Yan, Hu Yuan
State Grid Hebei Economic Research Institute, Shijiazhuang, Hebei, 050000, China
Corresponding author’s e-mail: bsbbwn@163.com

Abstract. Based on the current status of transmission and transformation project design management, the concept of lean design is highly integrated with the means of three-dimension design so as to innovate the new mode for the full-process design of transmission and transformation project, as well as construct the three-dimension design of power grid project with the features of Southern Hebei Power Network. Through the standardization construction of three-dimension design technology, lean construction of design quality and profound application construction of engineering practice, it is able to unify the design standard, enhance the design quality, rebuild the business process and deepen the design practice. This article realize the precise development of budge, as well as reach the targets of strengthening the engineering intrinsic safety and obtaining the good economic benefit.

1. Introduction
The three-dimension design technology of power transformation project for the power industry has entered the stage of rapid development in recent years. In terms of this demand, it is urgently required to launch the standardization construction of three-dimension design technology, lean construction of design quality and profound application construction of engineering practice, as well as the three-dimension design system research of full-process control construction so as to form the three-dimension design standardized system featured with Southern Hebei Power Network[1]. It realize the resource sharing for three-dimension design achievements of Southern Hebei Power Network, promote the linked collaboration of design and construction so as to reach the targets of unifying the design standard, improving the design quality, rebuilding the business process, deepening the design practice and covering the full cycle of engineering construction.

The three-dimension design standardized and lean construction is to analyze the key linkage of currently constraining the design quality and design efficiency based on establishing the three-dimension design standard system applies to the Southern Hebei Power Network, developing the standard three-dimension model construction process and constructing the “Three-Dimension+Modularization” sample stand general design plan. In terms of the modeling efficiency issue of three-dimension model of construction drawings, this paper explores the lean modelling method, as well as regulates the drawing mode as for currently the three-dimension design drawings are not standard and the functions are not complete. Finally reach the purposes of continuously enhancing the three-dimension design efficiency, optimizing the design process and improving the design quality[2].

*Corresponding author.
2. Deepen technical management, develop transmission and transformation series standard

Combined with the three-dimension design series standards and three-dimension design platform characteristics of State Grid Corporation, it is required to establish the three-dimension design management series standard system for Heibei Company so as to enable the tacit knowledge to be explicit, individual knowledge to be organized and internal knowledge to be standard. Rapidly promote the still qualification of designers, as well as regulate the work such as three-dimension design platform management, user operation, modeling of equipment model base. Develop the complete technical process documents, adapt to the new design requirements, and regulate the relevant work in each design institute of Hebei Company.

**Table 1** Main content of Transmission Line Three-Dimension Design Platform Pole and Tower Model Base Modelling Standard

| Main Structure and Content |
|-----------------------------|
| 1. Scope                  | Clarify the main content and applicable scope of this Standard |
| 2. Normative Reference     | Mainly list the relevant standards of deeply regulating the primary design and construction design content of overhead transmission line |
| 3. Terms and Definitions   | Define the terms appeared in the text of standard |
| 4. General Requirement     | Raise the general principles of standard execution |
| 5. General Regulation      | Raise the principle requirements to model classification, property and modelling method etc. |
| 6. Materials, Equipment, Facility Modelling | Raise the unified modelling content, modelling requirements and modelling method for the models of earth wires, insulator string, hardware fittings, pole and tower, grounding device and accessories of pole and tower in the overhead transmission line. |

Appendix A: Wording description of this Standard, belong to the normative appendix

Appendix B: MOD parameter model format

Appendix C: Property information sheet

Appendix D: Ground feature category code

This paper makes the statistics to the drawing information of electric major equipment with high application density in Hebei Company since the “11th Five-Year Plan” by the means of “Big Data”, as well as applies PCA (principal component analysis) and Bayes classifier to determine the key factors so as to abstract the information of equipment and manufacturer etc. to develop the model base contents. According to the contents, it is able to establish the universal model base for the construction drawings of transformer substation and line, as well as develop 9 categories 26 transformer first and secondary equipment model bases, 3 categories 26 civil engineering model bases, 18 line, pole and tower model bases. The model bases are centralized to manage and unified to issue by the provincial company.
In order to give consideration to the expandability of model base, this paper applies PDCA circulation method to establish the “feedback-handle-update” mechanism. Afterwards it adopts comprehensive application demands for the specialties e.g. construction, transportation inspection etc. to cooperate with the designing requirements of each design unit so as to realize the adjustment and updating to the universal model base, as well as optimize the integral resources, improve the working efficiency and promote the three-dimension technology enhancement of designing industry.

3. Integrate Professional Work, Establish Standard Operation Mode
First of all is the deployment of universal model. Import the three-dimension universal equipment model of State Grid Corporation through GIM modelling tool, and check the completion of model. Secondly is the deep secondary modelling of construction drawing. According to the Transformer Substation (Convertor Station Three-Dimension Design Modelling Standard), adjust the model depth to the product model depth, and generate the secondary modelling depth list. Thirdly is the dimensional adjustment for key positions. Capture is key positions and key dimensions, carry out the secondary modelling and modification compared with the manufacturers’ drawings. Fourthly is input of model body and equipment property. Develop the equipment property sheet one on one to clarify the key parameters and featured properties of equipment, and then unify to import in GIM property so as to realize the synchronous marking and synchronous tracking of model property.

Example of Modelling Content:

**Table 2 Building Basic Modelling Content Sheet**

| Type            | Component | Primary Modelling | Construction Drawing Model |
|-----------------|-----------|-------------------|---------------------------|
| Foundation      | Pile      | V                 |                           |
|                 | Pile caps  | V                 |                           |
|                 | Independent foundation | V |                           |
|                 | Strip foundation | V |                           |
|                 | Raft foundation | V |                           |
|                 | Foundation pad | V |                           |
| Outer wall of basement | V | V             |
| Foundation mat  | V         | V                 |                           |
| Foundation beam | V         | V                 |                           |
| Drain pit       | V         | V                 |                           |

**Table 3 Concrete House Modelling Content Sheet**

| Type             | Component | Primary Modelling | Construction Drawing Model |
|------------------|-----------|-------------------|---------------------------|
| Architecture     | Door      | V                 | V                         |
|                  | Window    | V                 | V                         |
|                  | Wall      | V                 | V                         |
|                  | Aproll    | V                 |                           |
4. Improve Design Quality, Construct “Three-Dimension+Modularization” Sample Station

This paper establishes the construction drawing deep “three-dimension design+modular construction” sample station of provincial company level so as to develop the deep three-dimension and modular universal design plan of construction drawing. Carry out the investigation and survey to the major equipment (main transformer, GIS device, switch cabinet, capacitor) of 220kV and 110kV projects that have been applied since the “11th Five-Year Plan” for the Southern Hebei Power Network, as well as select four universal design plans of covering the indoor/outdoor application demands of Southern Hebei Power Network (HE-220-A1-1, HE-220-A3-2, HE-110-A1-1, HE-110-A3-3) to perform the three-dimension design for entire station.
After obtaining the three-dimension model of entire station, this paper applies three-dimension cutting method to transform the three-dimension mode of entire station to the two-dimension construction drawing in order to further guide the three-dimension construction drawing design of each design institute, as well as develop the Modular Three-Dimension Universal Design of Southern Hebei Power Network manual according to the current drawing requirements.

**Figure 3** Design Flow of “Three-Dimension+Modular Construction” Universal Design

**Figure 4** Aerial View of HE-220-A1-1 Sample Station
Oriented with the “design preparation to design delivery” process, this paper determines the lean and complete plan by the means of VOC and the collective wisdom and efforts, as well as carries out the maturity management to the applicable subject and evaluate the improvement effects on a regular basis so as to form the lean and improvement atmosphere of “building sample, point to area, rapidly copying the mature experience”, and finally fulfill the purpose of enhancing the comprehensive efficiency of project.

This paper performs the lean three-dimension design quality improvement work, as well as carries out the software improvement and quality enhancement work as for the issue that currently it is unable to realize the two-dimension drawing of anti-thunder protection three-dimension design within the scope of State Grid. It also researches and develops the anti-thunder two-dimension drawing module, and raises the method of three-dimension design and two-dimension drawing for the anti-direct thunder protection scope drawing with innovations within the nationwide scope, including the protection scope drawing and joint protection scope sheet (automatically generated).

![Figure 5 Anti-Thunder Design](image)

5. Engineering Example
The three-dimension standard and lean design practice is carried out by relying on the first-batch 220kV modular transformer substation trial project of State Grid Corporation---Longquan 220kV Transformer Substation New Project. This research selects the modular sample station 220-A1-1(10) plan as the design template of construction drawing, performs the local practical adjustments according to the features of primary design plan on this basis, as well as adopts the means e.g. safety static distance calibration, collision test etc. to perfect the rationality of modular design plan. Through making a comparison with the traditional two-dimension design means, the following effects will be acquired:

Material statistics is more precise: The accuracy rates of cable duct, road engineering statistics are respectively improved by 1.3% and 2.1%; The accuracy rates of distribution device room, guardroom steel engineering statistics are respectively improved by 4.7% and 3.7%; The accuracy rates of 110kV and 220kV structural steel engineering statistics are respectively improved by 3.9% and 2.5%.

Enhance the accuracy of construction: The comprehensive collision check of underground foundation concealed work is performed to reduce the error, missing, collision and shortage of design; The electric distance and risk calibration are accurate and intuitive to ensure the reasonable design margin; The layout of three-dimension cable is intuitive and vertical to reduce the construction error.
6. Conclusion
Through carrying out the standardization construction of design technology, lean construction of design quality and profound application construction of engineering practice, as well as the three-dimension design system research of full-process control construction, it is able to form the three-dimension design standard system featured with the Southern Hebei Power Network. The achievement and resource sharing mechanism of economic research institute and each local design institute has been established. The establishment and application of this system improve the design depth and realize the lean design so as to reach the purpose of strengthening the intrinsic safety of project, ensure the reasonable design margin and reduce the construction error. This study enhance the engineering construction management quality, facilitate each participating party to intuitively master the design plan. Through the use of three-dimensional means to improve the efficiency of construction management, the project eventually achieved good economic benefits.

References
[1] Peng Xiangyang, Chen Chi, Rao Zhangquan, Yang Bisheng, Mai Xiaoming, Ke Wang. Power line safety inspection and intelligent diagnosis based on multi-sensor data acquisition of unmanned aerial vehicles [J]. High Voltage Technology, 2015, 41(01): 159-166.
[2] Wang Yongsheng, Lu Xiaoping, Zhu Hui, et al. Application of UAV Real Scene 3D Modeling Technology in Water Conservancy BIM [J]. Surveying and Mapping Bulletin, 2018 (3): 126-129. DOI: 10.13474/J. Cnki.11-2246.
[3] Wang Guozhen, Zhou Peng. Preliminary study on three-dimensional digital design of 500kV substation based on bentley platform[J]. Power construction,2015,11:217-218.
[4] Li Suo. Research on Visual Design of 3D Structure Model of Hydropower Station Based on BIM[D]. North China Electric Power University,2012.
[5] Ebrahim P. Karan, Javier Irizarry, John Haymaker. BIM and GIS Integration and Interoperability Based on Semantic Web Technology[J]. Journal of Computing in Civil Engineering, 2015.
[6] C. Wang, B.C. Khoo, K.S. Yeo. Elastic mesh technique for 3D BIM simulation with an application to underwater explosion bubble dynamics[J]. Computers and Fluids,2002 (9).