# The Application of BIM in Small and Medium-sized Smart Substation－A Case Study of Prefabricated Building Design

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**Abstract.** Smart substation is an important part of the smart grids. The design, fabrication and erection of prefabricated buildings in the substation have been a key problem for project construction. This paper discusses a new mode of communication on the project of small and medium-sized smart substation with BIM (Building Information Modeling). With the characteristic of BIM, involving the 3D visualization, parametric modeling and interoperability, the process for creating models of prefabricated steel frame building in substation and the practical workflows for design are researched. Result shows that BIM improved design more efficient and effective, but the creating of models must apply various software and the different data exchange strategies should be adopted according to the type of the system and the complexity of the models. It doesn't require merely technology research, the relative standards, policy, management of BIM are also to be concerned.

## 1. Introduction

As an important part of the smart grids, smart substation using intelligent device based on the information digitization, communication networking and information sharing standardization requires modular construction. The prefabricated buildings and electrical equipments in the substation change the construction traditional mode, which characterized by "standardized design, factory fabrication, and prefabrication construction". National Building Information Model Standard Project Committee (NBIMSPC) defines BIM in the following manner: “BIM is a digital representation of the physical and functional characteristics of a facility. It consists of a single, shared source of information about an installation, constituting a reliable database for decisions throughout its lifecycle, from preliminary studies to the end of its useful life” [1]. The 3D visual model with detailed data, including geometric, professional attributes and status information of buildings and equipment components can be made, and the effective transmission and real-time sharing of information can be realized with this modeling. It changes the traditional cooperation mode of each participant in the project. In recent years, BIM is using wildly throughout the whole lifecycle of the engineering and improving the performance of itself at the same time, including planning, design, construction etc.

The paper demonstrates a new procedures of design for small and medium-sized smart substation based on BIM, and illustrates the application design method of a prefabricated steel building in smart substation. It provides useful technical reference for the fine design of small and medium-sized smart substation.

## 2. Prefabricated steel buildings design in smart substation

At present, the traditional design uses CAD technology that only relying on the engineer's spatial visualization ability and drawing skills to complete the work. The economy and optimization of the construction are lack of control, and the long period caused low efficiency. It is difficult to satisfy the owner's demand for fine construction and life cycle management, especially after the popularization of prefabricated steel building which is fabricated in shop and assembled on site using in the smart substation.

A building and structure design method was given based on BIM that applied earlier to fabrication and erection of steel structure, to build the important civil engineering digital model of electric substation.

### *2.1. BIM platform*

In China, the regional level company has chosen to enhance its electric substation design practices with Bentley Microstation platform and Bentley Substation by taking advantage of its integrated set of capabilities combining intuitive 3D modeling, electrical design functionality, and automatic bills of materials and report generation [2]. But the cost of Bentley Substation is too expensive to pay for small and medium-sized companies, and the operation and method based on international platform is not suitable for local designers. Autodesk Revit has been the test platform for its open API and good performance of building design, especially during the improvement of electrical design functionality.

### *2.2. High efficiency architecture design*

The core of BIM is established the virtual 3D models in computer [3]. These models have object attributes can not only be used for graphic visualizations but also provide much data integration and design analysis, including physical status information of buildings and equipments. And these improve the engineering information to the greatest extent in the design of substation and provide a reliable and valuable model information to owners, designers, engineers, and manufacturer.

The application of project model visualization plays a very important role in electrical engineering. For example, the professional construction drawings usually have the information of each member or equipment, which is expressed by line required to consider the real dimensions and configuration. BIM provides a visual method, so the participants can convert the past two-dimensional line graphics into three-dimensional graphics, which makes communication easier in the visual state during design, construction and operation process.

Using Revit platform and other plug-in of BIM, we made switching room model, as shown in figure 1. The 3D model is designed directly rather than being generated from multiple 2D views. It can be used to visualize the design at any stage of the process with the expectation that it will be dimensionally consistent in every view. It greatly improves and optimizes the engineering design by strengthened virtual construction checking in the early stage. So we can achieve effective coordination in all participating, reduce the safety problems in the construction of substation, and save time on reworking.

### *2.3. Fine structural design*

In the traditional structure design, structural analysis depends on the effective data from architecture. But it will make different structure model for the complexity of the structure design stage associated with the capacity to carry load and resist force in the same building.

Data exchange between structural analysis software and structural modeling of BIM has been a key problem to research on the application of BIM technology in structural design. We use structure

design software, such as YJK (a Chinese structural design software), to exchange data from the aspects of IFC standard, Revit API Platform and Excel data format. The test results show that IFC standard is only suitable for the information exchange of structural physical model, and the sequential structural analysis and reinforcement entity configuration receives very huge restriction; the information exchange interface based on Revit API is feasible in structural analysis and design，also there are many problems such as the instability of the interface to be solved and the method based on excel file format is stable during the data exchange process which depends on whether the software can export and import excel file [4].

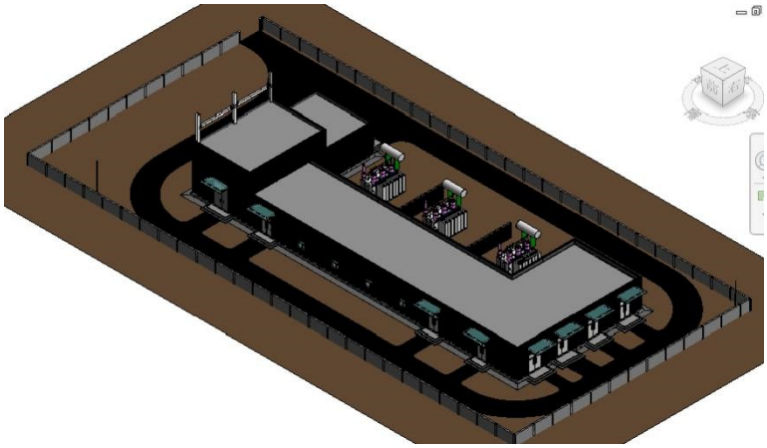

Figure 1. Main prefabricated building model in smart substation.

Through the indirectly conversion model between Revit and structural design software, we achieved data sharing from architecture model to structural analysis, which can greatly improve the efficiency. A 3D structural model for analysis is shown in figure 2. Figure 3 and figure 4 shows the details of members and connections in Revit by exchanging model.

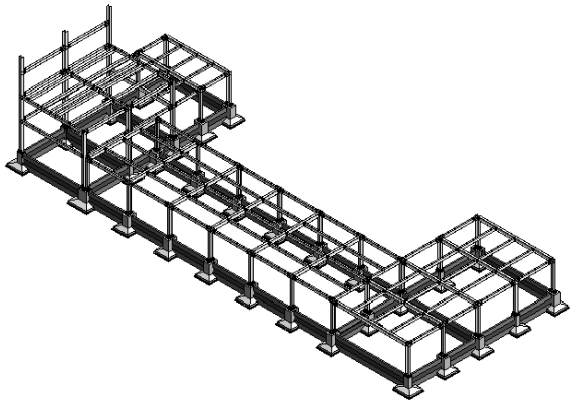

Figure 2. Steel structural model for analysis.

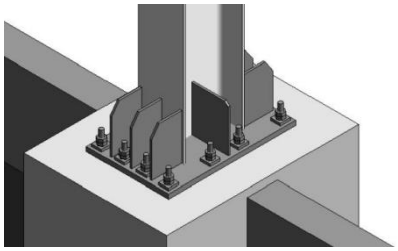

Figure 3. Detail of column bases joint.

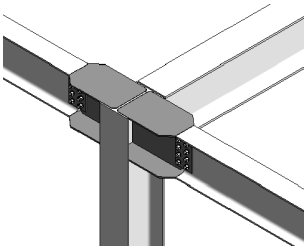

Figure 4. Connection of beam-column joint.

*2.4. Collision detection*

After building the model, we can carry out collision detection in the early and middle construction stage. It not only can avoid the collision site map back to modify the problem, improve the accuracy of drawing, also can speed up the construction progress and reduce the construction cost. First, the model of architecture, structure and MEP (Mechanical, Electrical & Plumbing) are to be made by Revit platform, and then link to Autodesk Navisworks for collision detection. Finally, the problems that may be encountered in the construction displayed in collision detection should be analyzed and adjusted, such as a collision between pipeline and foundation wall in the substation.

*2.5. Engineering quantity statistics*

The combination of BIM and 3D digital technology explores 5D modeling method that can be used for quantity calculation [5]. As long as achievement of data transfer with BIM, engineering quantity statistics of smart substation will be more accurate and efficient, which makes the owners, managers, designers, engineers, and contractors more clearly to know the works programme and project cost. It will bring huge impact on power engineering cost.

## 3. Conclusion

This paper measures BIM use in the design stage of smart substation. By integrate of Revit platform, and others software, the design procedures of prefabricated building in the small and medium-sized smart substation have been tested. The results shows that the 3D visualization, function parameters, digital information and other characteristics of BIM technology improves the quality and efficiency of building design for the smart substation. The following conclusions can be drawn within the limitation of this study:

(1) Autodesk Revit has good performance to be a software platform utilised to design small and medium-sized substations, especially during the improvement of electrical design functionality. Components (known as family in Revit) are typically inserted and moved/rotated into required position. Examples include doors, girders, columns, walls, joints of buildings and transformers, power lines etc of equipments.

(2) Tests of data transformation from BIM model to structural analysis model between Revit and YJK have shown the geometrical information and a little non-geometrical information can be exchanged Using API methods. It reduces the time of rebuild the structral model and quite improves the design efficiency.

(3) The digital model based on BIM technology has been built needs a new mode. The application of multi-specialty coordination and multi-software makes design more difficult that traditional work. Hence, design life for most building structures using BIM exceeds the length of time for traditional work.

Nowadays, the application of BIM has mainly focused on visualization of 3D modeling, and changed to the interoperability and more valuable aspect. During the promoting development of digital design technology in State Grid Corporation of China, not only technology but the relevant policy, standards and uncertain management system are also to be researched.

**Acknowledgments**
This work was financially supported by State Grid Zhangjiakou Power Supply Company 2016 Foundation and Youth Foundation of Hebei Educational Committee (QN2017323).

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