Study on secondary deepening design of exterior wall panel of Substation Prefabricated Building

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Abstract: With the continuous progress of the manufacturing industry and the urgent demand for new building forms in the electric power industry, the prefabricated steel structure buildings have been widely applied in the substation design of State Grid Corporation of China, which can effectively reduce the wet operation on site and the project cost. This paper takes the exterior panel design of prefabricated steel structure building in substation as the research object, and explores the technical application of the secondary design of exterior panel of prefabricated steel structure building through combining the actual project and the existing wall panel type, which provides a reference for the development direction of prefabricated building in the future.

1. Introduction
In 2017, the State Grid Corporation of China will fully implement prefabricated substations in power transmission and transformation projects above 35kV. First, it will save land and implement the construction policy of 'ensuring safety in better, reliability, economic applicability and conformity with national conditions'. The second is to reduce wet field operation, achieve factory processing, site rapid assembly, which will be able to greatly improve the design quality and construction efficiency of the substation[1]; Third, the main materials of the prefabricated building can be fully recycled, which has good benefits in shortening the construction period, saving water and materials, green environmental protection, etc.

As the main building structure of the substation, the secondary deepening design of the prefabricated building seriously restricts the construction and installation in the later stage. The technical application of the secondary deepening design of the exterior wall panels of the prefabricated steel structure building is actively carried out, which provides a reference for the development direction of the prefabricated building in the future.

2. Application of prefabricated buildings in substation engineering
At present, the exterior wall panels of prefabricated buildings commonly used in substations are mainly factory prefabricated metal sandwich panels and field composite fiber reinforced cement board system, in addition, factory prefabricated non-metal sandwich board system is also used in a small number of projects.

2.1. Factory prefabricated metal clad sandwich panel exterior wall
Metal exterior wall system is mainly metal sandwich composite board, which refers to the metal as the surface material, polyurethane, polystyrene and rock wool as the core material, through the binder
composite of metal surface insulation composite board. It has remarkable performance in fire prevention, heat insulation, environmental protection and other aspects, and it also has the characteristics of good stiffness, reliable installation, short construction period, anti-scratch protection and so on.

2.2. Field composite non-metallic surface sandwich panel exterior wall
Non-metal exterior wall system is generally composed of non-metal exterior wall panels and wall beam supporting structure system. Non-metal outer wall panels are usually equipped with waterproof, thermal insulation and other integrated decorative plates.

At present, non-metal wall panels in the domestic can be commonly used types of board gypsum board, fiber cement board (FC), expanded leech stone, autoclaved aerated concrete board (ALC), gypsum hollow strip board or large board, high fiber cement composite wall board, vacuum extrusion fiber cement board (ECP) and so on. The exterior wall system of substation building usually adopts vacuum extruded fiber cement board (ECP) exterior wall system.

Vacuum extrusion fiber cement board (ECP) composite exterior wall system generally adopts ECP exterior wall + air layer + thermal insulation layer + light steel keel gypsum board or non-masonry inner wall, and all materials are completed in the factory and assembled on site.

2.3. Factory prefabricated non-metal clad sandwich panel exterior wall
At present, there are a small number of manufacturers using prefabricated non-metal surface sandwich panel exterior wall system in the market. The main structure of the board is: that 16mm fiber cement board is used on the outer side of the two sides (coating decoration), the middle layer is 100mm thick rock wool (insulation material), and the frame is fixed by aluminum alloy in the frame.

3. Secondary deepening design of exterior wall panels of prefabricated buildings
The exterior wall panel in prefabricated steel structure buildings are relatively minor position in the design of the node design, often need to clearly in the contract bid to deepen the construction units, and design institutes to provide drawings contain only technical requirements and some key nodes, the nodes to the bid for the secondary design, after approved by the original design unit[2].

On the one hand, the design institute is responsible for the design of the key parts of the exterior wall panels, and the design of the secondary parts is coordinated by the factory. On the other hand, the node designed by the experienced large steel structure processing companies is more practical, which is easy to process, transport and installation, cooperation between the two sides, and is more conducive to improve efficiency and cost savings.

3.1. Layout of exterior wall panels
According to the architectural structure design drawing, the secondary deepening plate typesetting design is carried out to ensure the plate blanking is optimal, fastest and most economical, avoid unnecessary waste, quickly calculate the engineering quantity, and realize the parametric typesetting design. In principle, horizontal or vertical layout can be selected, and the width of the plate shall not be less than 300mm. The plate is disconnected from the door, window and hole, and the plate is arranged by the way of hanging up and fixing down. The whole frame keel is set at the entrance of doors and windows, and the self-tapping screw is fixed on the plate around, so that the plate suspended and fixed on the bottom is connected reliably, which can realize the overall stiffness and stability of the wall[3].
3.2. The support of exterior wall panel
The common assembly type external enclosure wall is supported on the main structure. The deformation of the main structure under the action of load or earthquake may have adverse effects on the external wall, so it is necessary to reasonably choose the supporting form of the wall on the main structure. The common supporting form of external wall can be divided into line supporting connection and point supporting connection. The line supporting connection is complex in load, earthquake action and deformation of main structure, and the point supporting connection is more widely used in engineering because of its simple bearing condition than line supporting connection. According to the different forms of constraint, point support connection can be divided into translation type, rotation type and fixed type.

3.3. The connection of Outer wall panel
The installation method of the outer wall panel is mainly hinged with the beam and column, and the vertical installation is generally used. The height of the board is usually the layer height, and some are horizontally installed. The two ends of the vertical or horizontal wall panels should form a hinged structure, and the design is calculated according to the simple supported plate model at both ends[4]. In the part of the building that is just built and under construction, one side of the outer wall panel is connected with the beam, and the adjacent side is connected with the column, so as to form the connection mode of the adjacent two sides simply supported, while the other two sides are free.

3.4. The highlights of Second deepening design
The first one is the outer wall panel seamless corner. The corner position of the outer wall panel is designed as a whole board, forming at a time, without on-site splicing, and the corner is straight and beautiful.

The second one is the integration of the hole. The most complex part of the whole building is the connection between the entrance of the cave and the inner and outer walls, and the natural sealing of the connection is the difficulty of the whole building. Simplify complex problems through integrated modular prefabrication is the key to deal with these parts. Through three-dimensional BIM modeling, a three-dimensional model of the edge collection is built, and the factory carries out three-dimensional processing according to the model, and the site is installed as a whole. Appearance and quality are guaranteed[5].

Figure 1. Layout effect drawing of exterior wall panel
The third one is integrated overhanging eaves. After the second deepening of the overhang eaves, the thick aluminum plate is directly welded into a whole by the factory. The whole installation requires higher accuracy, and the speed and quality are greatly improved. Each can save about 3 hours.

The fourth one is integration keel. After the secondary deepening design of the outer wall panel keel, the connecting parts are preset on the beam, which can save about 200 hours of work for welding the connecting parts and repairing the paint on the spot, and the safety and quality are also more guaranteed.

The fifth one is the integration stair. Because the structure and the inner wall do not deepen synchronously, the general transfer position will leave a certain adjustment gap. In the later construction, decorative materials are used to do the sealing and closing. After the second deepening design, there is no such problem. Two sets of stairs can save about 10 hours of closing time, while the appearance is also greatly improved.

4. Conclusions
The secondary deepening design and application of the exterior wall panels of prefabricated steel structure buildings can effectively reduce the cutting and assembling of the wall panels on site and improve the quality and efficiency of engineering design. Through three-dimensional BIM modeling, factory three-dimensional processing and on-site overall installation, the construction appearance and quality requirements can be met, and the multi-link connection can be realized, which is conducive to improving the project quality, shortening the construction period, saving manpower and material resources, and laying a solid foundation for building an environment-friendly and energy-saving society and promoting the construction of green power grid.

References
[1] Chen, J.J., Sheng, S.Y., Huang, D.Y. (2018) Study on the integration of substation prefabricated building structure. Power Survey and Design., (S2): 70-75.
[2] Wang, H.F. (2013) Optimal design of prefabricated building in Substation. Building Materials Technology and Application., (06): 41-43.
[3] Xu, Y. (2015) Study on design of precast concrete exterior wall panels for prefabricated building. Architectural Skill., (10): 82-84.
[4] Liu, Y., Zheng, Y.C., Wei, Z.Z. (2020) The Selection of wall panels for prefabricated substation building. Shanxi Buildings., 46(21): 137-139.
[5] Li, S.H. (2018) Research on the application of digital 3D design in substation. Engineering Electrical Engineering., (3): 103-108.