Research on design of the prefabricated foundation in substations

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Abstract: With the development of power engineering, higher requirements are put forward for construction period, project investment and social environment. Traditional wet operation methods restrict the rapid development of power engineering construction. The use of prefabricated foundations in the design of substations can effectively reduce on-site wet operations, reduce construction cycles, save labor costs and increase assembly rates. This article takes the prefabricated foundation design in substation as the research object, combines actual engineering and existing construction technology, explores the technical application of the prefabricated foundation design in substation and provides a reference for the future development direction of prefabricated buildings (structures).

1. Introduction
At present, the State Grid Corporation of China requires the comprehensive implementation of modular construction of substations and encourages the use of prefabricated components in substations. It can reduce wet operations, improve the efficiency of engineering construction and reduce environmental pollution [1]. The above-ground buildings (structures) in the substation can be assembled with steel structures and they have been fully promoted. Therefore, it is the design of foundations that affects the construction period and assembly rate of the substation. The foundation of the power distribution equipment building and the foundation of the main transformer are large in volume and easy to solidify in size. This article takes the foundation of the power distribution equipment building and the foundation of the main transformer as a case to carry out the technical research of the prefabricated foundation design in the substation, which provides a reference for the future development of prefabricated buildings (structures).

2. The situation of research on the prefabricated foundation
In the last century, the former Soviet Union conducted theoretical research on prefabricated foundations and obtained some results[2]. The research content is biased towards the form of large blocks. The main research directions are: discontinuous foundation, ribbed foundation and grid foundation.

Gerszewski [3] designed a circular and prefabricated concrete foundation component, which can be flexibly arranged under the foundation beam or wall. The components are connected and reinforced by steel parts and are connected to the upper structure through the anchoring steel reserved outside the component.

Adams [4] designed a prefabricated component of the block foundation. The block component is reserved for reinforcing steel grooves. During the on-site construction, the reinforcing steel layout is
completed. It is flexibly spliced by the cast-in-place concrete triangular grooves and poured together with the superstructure. Thereby, the strip foundation under the wall is completed.

Domestic scholars have long applied the concept of prefabricated concrete foundation in industrial plants. The specific manifestation is an independent foundation under the column with a reserved cup mouth (the cup foundation) [5]. The specification gives a detailed description of the cup foundation. Structural requirements parameters. According to the anchoring and construction hoisting stability, the column insertion depth parameters are given, the cup wall thickness and cup bottom thickness of the reserved cup opening of the foundation and the reference value of the structural reinforcement of the cup wall are given.

The research results at home and abroad and the application of prefabricated foundations in actual projects show that it is feasible to use prefabricated foundations in substations in terms of safety and technology.

3. Design of the prefabricated foundation in substations

The foundation of the power distribution equipment building and the foundation of the main transformer are large in volume and easy to solidify in size. This article takes the foundation of the power distribution equipment building and the foundation of the main transformer as a case to carry out the technical research of the prefabricated foundation design in the substation.

3.1 The foundation of the power distribution equipment building

The foundation of the power distribution equipment building adopts the assembly type. After the combination, it becomes the flexible expansion foundation. As shown in Figure 1, the fabricated foundation is generally composed of three parts:

1) The bottom foundation slab: it is a reinforced concrete slab. Connecting bolts are pre-embedded in the corresponding position of the cross-shaped connecting beam groove and the parts are connected into a whole through bolt rods after assembly.

2) The central cross-shaped connecting beam: it is a reinforced concrete beam with a beam section of 400mm × 200mm (width × height). The four limb beams and the central part of the connecting beam are respectively reserved for bolt holes for passing through bolts. Its main function is to connect the foundation slabs of the upper and lower layers into a whole without displacement in the horizontal and vertical directions. In the vertical direction, they are fastened by bolts and rods to connect them as a whole without vertical relative displacement.

3) The upper panel of the foundation: it is a reinforced concrete slab with a tapered shape. Bolt holes are pre-embedded at the corresponding position of the cross-shaped connecting beam groove and a plane for fixing bolts is set at the bolt hole position on the surface for passing through the bolt rod after assembly, which connects each part into a whole. A hole with a diameter of 500mm and a depth of 100mm is reserved at the center of the cross-shaped connecting beam corresponding to the bolt position. After the bolt is tightened, it is filled with fine stone concrete to close it so that the top surface of the conical foundation is a flat surface, which is convenient for installing the pillar steel plate. The corresponding number of high-strength bolts are pre-embedded at the corresponding position of the top and the column foot steel plate and the upper column foot steel plate is connected by high-strength bolts when it is installed.
Figure 1. The foundation of the power distribution equipment building

The bottom base plate and the upper base plate are both rectangular and placed in two mutually perpendicular directions. A groove with a depth of 100mm, a width of 400mm and a width of 200 are reserved at their centerline and the splicing surface of the two splicing plates, respectively, for placing the central cross-shaped connecting beam.

3.2 The foundation of the main transformer

The main transformer foundation adopts the assembly type, which is improved and innovated on the traditional structure. According to the wheelbase between the main transformer foundation beams, the original raft foundation is divided into four pieces and the connection form of socket opening is adopted between the four pieces, as shown in Figure 2. When splicing, apply special structural glue on the splicing surface to make it better integrated. Longitudinal through holes are reserved between the four rafts. After the four rafts are spliced in place, prestressed steel bars are used to connect them as a whole, which ensures the integrity of the four rafts. After the structure is optimized, the thickness of the raft can be reduced compared to the traditional construction scheme, saving material consumption.

Figure 2. The foundation of the main transformer(1)

In order to facilitate construction and reduce on-site wet operations, the equipment buttress and the bottom raft are further separated. As shown in Figure 3, the buttress and the bottom raft are connected by bolts. As a result, the disassembled parts are prefabricated in the factory and then assembled on site, reducing the wet work on site. Only the components are connected by bolts and then the fine stone concrete is poured for sealing without other wet work.
After the main transformer foundation is split, the heaviest assembly component is the raft module, each weighing about 20 tons. Mechanized construction technology can meet the requirements of transportation and installation.

4. Conclusions
The application of prefabricated foundations in substations reflects the concept of modular construction of the State Grid Corporation of China. Compared with traditional cast-in-place reinforced concrete foundations, it has the following advantages:

1) It can give full play to the physical and mechanical properties of different materials, save materials and reduce cost.

2) With the continuous emergence of extreme weather, the dynamic load will gradually increase in the structure design. The use of a flexible foundation can make the upper structure have a better resistance to dynamic load, thereby improving the stability of the result to a certain extent.

3) After the prefabricated foundation is delivered to the site, it can be assembled in place at the designated location of the foundation pit, or it can be assembled on site and placed in the designated location of the foundation pit. The prefabricated foundation has a small volume and requires little soil excavation. It can reduce the amount of spoil, thereby protecting the ecological environment.

4) It is easy to dismantle. If the foundation is no longer in use, the prestressed steel bars can be directly cut and dismantled directly, which reduces the amount of foundation dismantling.

5) It is convenient for construction and reduces maintenance time. The prefabricated foundation does not have the process of pouring and curing on site, which is all bolted connection. It only needs to pour a layer of fine stone concrete to seal it as protection after the bolts are tightened.

6) The foundation can be constructed by machinery, which has relatively simple requirements for construction machinery and has good construction adaptability.

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