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Design of prefabricated foundation for 66kV tower assembly and simulation of mechanical properties and grounding current density distribution

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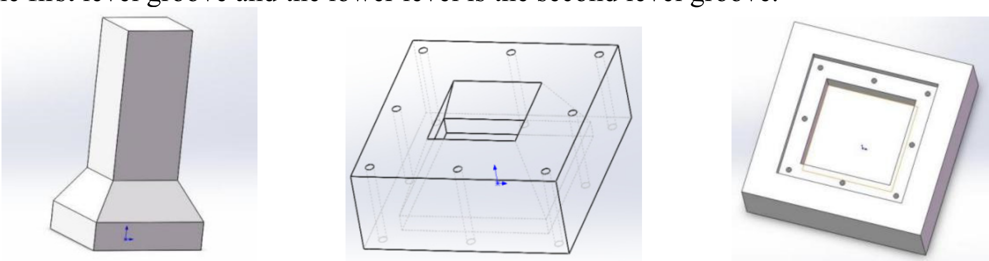
Abstract. Most of the existing transmission line tower foundations are cast-in-place foundations, and there are many obvious disadvantages of this operation method, such as its long construction period, poor generality, and inability to construct in winter. In this paper, we propose an assembly type prefabricated foundation for 66kV transmission line towers. And use SOLIDWORKS to simulate and analyze the mechanical properties of the foundation, analyze the current density distribution of the designed foundation with CDEGS simulation, and add reinforcement cage to optimize its current density distribution. The results show that the designed foundation meets the requirements of its working conditions.

1. Introduction

Most of the existing transmission line tower foundations are cast-in-place foundations, that means, mechanical excavation, foundation reinforcement tying, foundation concrete pouring, temperature control, maintenance, demolition, acceptance, earth backfill and some other steps will be done in the tower foundation construction site. In addition, the cast-in-place foundation has many shortcomings, such as high construction cost, construction process cannot meet the requirements of civilized construction and environmental protection, material cannot be recycled, poor versatility, and cannot be constructed in winter. Traditional wet operation methods restrict the rapid development of power engineering construction [1]. The prefabricated foundation means dividing the original cast-in-place foundation into two or more components, prefabricating them in the factory, and then transporting them to the construction site and assembling them. Obviously, in the case that both cast-in-place foundation and assembled prefabricated foundation can meet the working conditions, assembled prefabricated foundation has significant advantages in all aspects such as time efficiency, quality efficiency and economic efficiency. Under the condition of lightning impact, good dissipation of the tower foundation is an important factor to ensure the stability of the tower foundation. Therefore, it is necessary to simulate the dispersion of prefabricated foundation and optimize it in the case of poor dispersion.

2. Assembled prefabricated foundation design scheme

2.1. Assembled prefabricated foundation components division and connection scheme
A typical step-type foundation is selected for division, which is divided into three parts: main column, step layer and pedestal, as shown in Figure 1, and the overall assembly is shown in Figure 2. The upper end of the main column is a cuboid, the lower end is a prism, and the lowest end is a short straight column. The shape of the groove inside the step layer has the same shape as the lower end and the lowest end of the main column. The pedestal is prefabricated with two levels of grooves, the upper level is the first level groove and the lower level is the second level groove.



(a) Main column (b) Step layer (c) Pedestal

Figure 1. Prefabricated foundation components

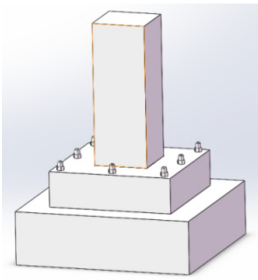


Figure 2. Assembly body

The upper end of the main column is pre-buried with ground bolts to connect with the tower foot, and the lower part of the main column fits into the groove of the step layer. The lower end of the step layer fits into the first level groove of the pedestal, and the lowest end of the main column fits into the second level groove of the pedestal, and the concrete interface adhesive is added between the fitting interfaces for connection. The connection bolts are pre-buried in the pedestal, and are inserted into the prefabricated holes of the pedestal and tightened for fixing.

2.2. Design of assembled prefabricated foundation dimensions
According to part of the foundation parameters in the "State Grid Corporation Transmission and Transformation Engineering General Design Transmission Line Hollowing Foundation Sub-book" 110 (66) kV voltage level transmission tower foundation 1ZTW1 sub-module (geotechnical category for powder soil) , the dimensions of the prefabricated foundation are designed. The schematic is shown in Figure 3, and the detailed dimensions are shown in Table 1.

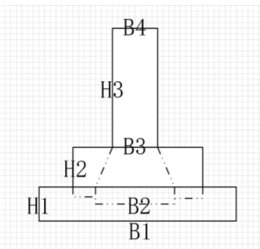


Figure 3. Schematic diagram of prefabricated foundation dimensions

Table 1. Size of prefabricated foundation.

Size code	Size value (m)
H1	0.6
H2	0.5
H3	1.6
B1	2.0
B2	1.0
B3	1.4
B4	0.6

3. Simulation analysis of mechanical properties of each component of assembled prefabricated foundation based on SOLIDWORKS

3.1. SOLIDWORKS simulation model building

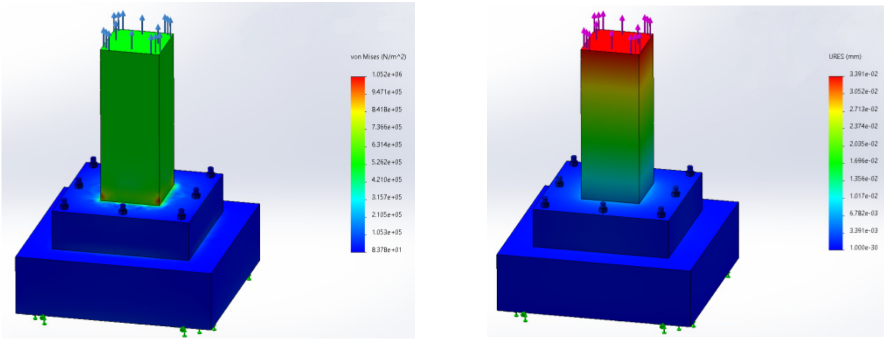
According to the division scheme and dimensions design of the assembled prefabricated foundation described in part 1, the model was built by SOLIDWORKS, and the material was set to C30 concrete with Young's modulus 30,000 MPa and Poisson's ratio 0.2. The upward pulling force Tmax =187kN and the downward pressure force Nmax=233kN. The situation of prefabricated foundation forces is shown in Table 2.

Table 2. Forces situation of prefabricated foundation.

Force	Force values
Upward pulling force T_{max} (kN)	187
Downward pressure force N_{max} (kN)	233
T_x (kN)	18
T_y (kN)	17
N_x (kN)	21
N_y (kN)	20
Root opening (m)	4
Rigid angle	42°

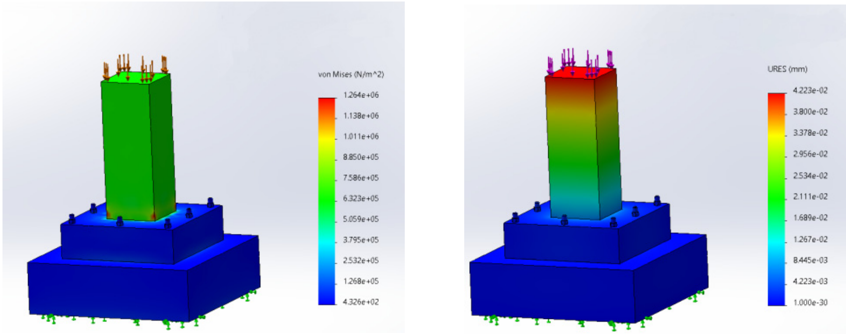
3.2. Analysis of SOLIDWORKS simulation results

As shown in Figures 4 and 5, the maximum stresses of the assembled prefabricated foundation under 187kN upward pulling force and 233kN downward pressure force are concentrated at the four intersection points between the straight column part and the prism part of the main column, and the maximum stresses are 1.052MPa and 1.264MPa, and the maximum displacements are concentrated at the upper end of the main column, and the maximum displacements are 0.03391mm and 0.04223mm, respectively. The overall force situation of the prefabricated foundation is good and no obvious deformation occurs.



(a) Stress nephogram (b) Displacement nephogram

Figure 4. Nephograms under upward pulling force



(a) Stress nephogram (b) Displacement nephogram

Figure 5. Nephograms under downward pressure force

4. Simulation analysis and optimization of natural ground current distribution of prefabricated foundation based on CDEGS

4.1. CDEGS simulation model building

The CDEGS model of assembled prefabricated foundation is shown in Figure 6. The vertical grounding pole has 16 φ22 reinforcement bars evenly arranged along a square with side length of 0.5 m, with hoop bars along the vertical direction, longitudinal bars and hoop bars distributed in both the step layer and the pedestal, and a 1.86 m × 1.86 m reinforcement network at the lower end of the pedestal, with concrete layer thickness of 0.07 m for all three prefabricated elements.The soil resistivity is 228Ω·m and the excitation current is set at 10A.

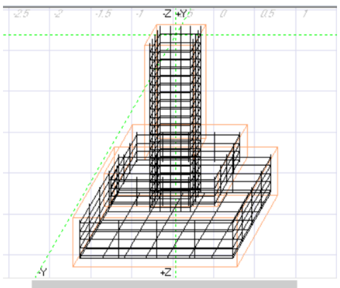


Figure 6. CDEGS model of Prefabricated foundation

4.2. Analysis of CDEGS simulation results

The simulation results of CDEGS current density distribution are shown in Figure 7, which shows that the maximum current density is 9.18A/m at the contact between the connecting bolt and the soil, and the connecting bolt plays the role of connecting and fixing the components of the prefabricated foundation. In serious cases, it may lead to the failure of the connecting bolts due to the deformation caused by heat. Therefore, in order to optimize the current density distribution of the prefabricated foundation, make full use of the natural grounding of the foundation and reduce the cost, a reinforcement cage can be added around the foundation. The simulation results after adding the reinforcement cage are shown in Figure 8, the maximum current density amplitude is no longer at the connection bolt, and the maximum value is also reduced.

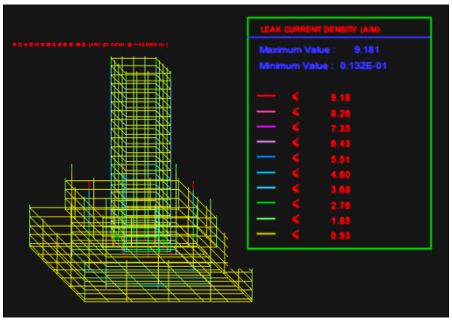


Figure 7. CDEGS simulation results

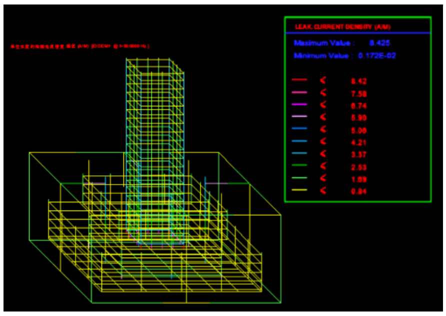


Figure 8. CDEGS simulation results of adding reinforcement cage

5. Conclusion

This paper proposes a new type of assembled prefabricated foundation for 66kV linear towers, and the following conclusions are reached through calculation and simulation of mechanical properties and natural ground current density distribution.

(1) The mechanical properties of the components of the new prefabricated foundation are simulated by SOLIDWORKS, which shows that the design scheme is feasible in terms of mechanical properties.

(2) The simulation study of the current density distribution of the new prefabricated foundation by CDEGS proves that the method of adding reinforcement cage can effectively improve the current density distribution.

Acknowledgments

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