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The Structure Design Optimization of Transmission Line Pole Tower Body

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Abstract. Tower as an important part of transmission line project construction, in the overall project construction cost accounts for more than 30%, to ensure the quality of project construction, improve the level of structural optimization, has a positive impact on the stable operation of the power system. Therefore, while gradually expanding the scope of electric power investment and construction, China has strengthened the research on the structure optimization design of transmission line tower body, effectively controlled the project cost and improved the quality of construction and installation in the comparative analysis. Based on the understanding of transmission line pole tower design theory, according to the current common foundation selection and specific requirements, this paper deeply explores the transmission line steel pole tower body operation platform, and carries on the verification analysis to the practice optimization design scheme. The final results show that the optimized design of the tower structure can better ensure the stability and security of power grid system construction and operation.

Keywords: Transmission line; Tower; The tower; Structure; The power system

1. Introduction

The tower structure design of transmission lines will use the limit state design method based on probability theory, the reliability of components should be measured and analyzed according to the corresponding indexes, and the design expression formula should be analyzed by the multiple coefficients of geometric parameters, material properties, loads and so on. In view of the operation of transmission lines in the current power system, the limit state of structure refers to the critical state that the structure or construction can meet the line safety under the influence of a specified variety of load combinations. [1]Generally speaking, this limit state is divided into two cases, one is the ultimate state of bearing capacity, the other is the limit state of normal use. In the specified time and conditions, the ability of a structure to complete a predetermined function is called the reliability of the structure, which specifically involves durability, applicability and safety. In essence, structural reliability refers to the probability of completing a predetermined function within a specified time and under specified conditions. For example, in the 500kV transmission line project, the actual specified time refers to the design base period of 50 years. This base period is only the base time needed to study the statistics of basic variables, parameters and time relations in the calculation of reliability, rather than the application time of building structure. The prescribed conditions refer to the basic conditions of normal design, construction and use, and will not consider the impact of human error; Predetermined function refers to the ability to withstand various forces that may occur during normal construction and normal use, have good working performance during normal use, and have sufficient durability under normal maintenance. Combined with the analysis of the optimization design flow chart shown in Figure 1 below, it can be seen that the design requirements of transmission line tower body are extremely high, with many corresponding technical requirements and complicated practical work content, which is one of the links that can best reflect the design level in the overall transmission line engineering design.[2,3]

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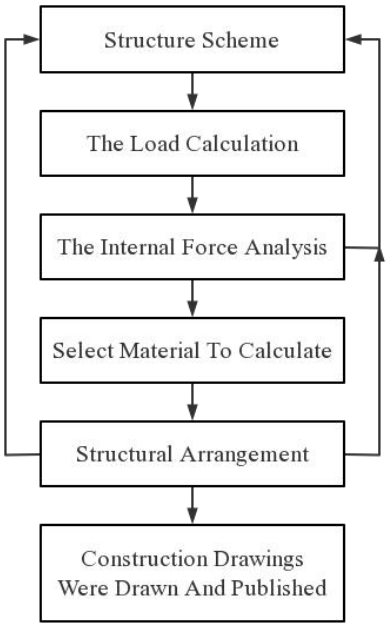

FIG. 1 Tower body design flow chart

As electric power is one of the essential and important energy sources for current social development, the construction quality of transmission lines directly affects the power supply efficiency, and tower is the most critical component of transmission lines. According to the practical investigation and research, in the past safety accidents, poor design of tower body foundation is the main influencing factor. Therefore, it is necessary to strengthen the control of relevant links during the construction and operation, so as to guarantee the safety and stability of power system operation on the basis. [4]Nowadays, when studying the structure of transmission line poles and towers, researchers in various countries have proposed a variety of foundation forms according to the existing research results, but they are mainly divided into two types: on the one hand, it refers to the large excavation foundation, on the other hand, it refers to the undisturbed soil foundation. Nowadays, the most common type selection of pole tower foundation in the construction of high voltage transmission line includes cast-in-place step foundation, plate pillar foundation and plug-in foundation. Plug-in foundations, for example, do not require footboards and bolts to connect. Instead, the main material is inserted directly into the column and anchored at the ends. The force of the whole structure is very simple, the eccentric bending moment and horizontal force of the foundation are small, the bottom plate and column are under pressure, which can effectively improve the force condition and reduce unnecessary material consumption. This type of foundation is more suitable in areas where there is no groundwater or where the foundation soil is hard molded. In the mountainous area, because the transportation conditions are too poor, the plug-in foundation can effectively make up for the defects of transportation, which is a simple construction and economic and practical structural design scheme. On the basis of integrating the research experience of structure design of transmission line tower in recent years, this paper puts forward a kind of simple operation platform, and carries on the deep research of the actual structure design optimization, so as to guarantee the safety and stability of transmission line on the basis.[5]

2. Method

2.1 Design Roadmap

The overall platform is composed of three parts: adjustable steel tube tower and cement pole,

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two sizes of iron chain hoop fixed parts, arc-shaped semi-circular rack ring structure parts and folding platform. Before the operation, the ascending personnel shall lift the simple folding operation platform of the steel pipe tower body of the transmission line to the designated position through the insulation rope at the pre-operation position. The personnel on the tower shall adjust the diameter of the steel pipe tower or the cement pole to fix it, and then adjust the contraction pressure by the screw to ensure the stable installation of the platform, and then the folding operation platform can stand for operation. The folding platform of the actual platform is shown in Figure 2 below[6.7]:

FIG. 2 Folding platform diagram

The simple operation platform of steel pipe tower for transmission line adopts epoxy resin rod material, which has the outstanding characteristics of solid structure, strong bearing capacity, reliable insulation, simple loading and unloading, 180° rotation and operation at any Angle, etc., to meet the requirements of field operation, and can effectively solve the limitation of live operation when the tower cannot stand.

2.2 Design Requirements

The whole structure includes holding hoop, rotating adjusting parts and standing platform. The platform is secured to the steel tube tower body by means of a hoop. After the platform is boarded, the operator can rotate the platform to the corresponding position using electric or hand gear components. However, the following points should be noted: First, the overall tool should be able to carry the weight of personnel and tools, the carrying capacity is not less than 200Kg; Second, the rotating mechanism should be able to rotate flexibly after the personnel board the platform, and can realize the rotation range of 180°; Third, the opening of hoop is adjustable structure, it is suggested to make two kinds of hoop, respectively applied to cement pole and steel pipe tower, the maximum diameter of hoop for steel pipe tower should not be less than 2.5 meters, the maximum diameter of hoop for cement pole should not be less than 0.4 meters; Fourth, the platform should be equipped with guardrail, guardrail should be able to effectively protect the safety of operating personnel; Fifthly, the whole tool is made of composite or alloy material, which can reduce the overall weight of the tool as far as possible while ensuring the strength, and is easy to use. Sixth, the tool should have a removable function, easy to carry[8.9].

3. Result analysis

Taking the design of transmission line tower body in a certain area as an example, and based on the systematic understanding of the comparison results of various schemes, specific strategies for structural design optimization are clarified:

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3.1 Tower body and legs

Generally speaking, the width of the opening at the top of the tower head, the width of the changing groove, the root of the tower legs and other factors can affect the slope of the tower head column and tower body, and both are also limited by the width of the changing groove. Therefore, in the design of variable groove width, the controlled width of electrical clearance circle should be regarded as a fixed value, and the slope of tower head column and tower body should be optimized respectively, which have different design effects.

On the one hand, tower head column slope optimization. The width of the variable groove is regarded as a fixed value, and the opening at the top of the column at the tower head is selected as the variable. The specific scheme is shown in Table 1 below:

Table 1 Scheme comparison results of tower head column

Plan	1	2	3	4	5
Top opening (M)	3.9	4.0	4.15	4.2	4.25
Slope change opening (M)	6.7	6.7	6.7	6.7	6.7
Calculating tower weight (t)	141.34	140.5	141.76	141.91	141.34
Tower weight ratio (%)	1.006	1.0	1.009	1.010	1.008

Combined with the analysis in the above table, it is found that the calculation result of this scheme is 4.0 meters as the width value, and the final result is very reasonable.

On the other hand, the optimized treatment of tower leg followed open. The specific design optimization results are shown in Table 2 below:

Table 2 Optimization scheme of tower leg slope

Changing slope mouth wide	6.7	6.7	6.7	6.7	6.7
Unilateral slope	0.10	0.105	0.11	0.115	0.12
Based on root open	17700	18250	18800	19350	19900
Tower weight (t)	141.8	142.0	140.5	140.6	140.8

Based on the analysis of the presentation scheme in the table above, it can be seen that the components of the corresponding computer weight system will use the materials of Q235 and Q345. Combined with the above scheme for optimization, the final results show that the opening of the variable groove is 6.7 meters, and the slope value of one side is 0.11. At this time, the consumption amount of tower material is relatively appropriate, and the basic force is very scientific. 3.2 Tower layout

In order to ensure the rationality of the length of the main material in the tower section, the basic characteristics of the applied materials should be given full play. This structure design mainly has the material yield point, the cross section area, the material length and other factors directly affect the bearing level. If the main material is controlled by strength, then the relationship between the selected cross section area and mature charm is directly proportional, in other words, the greater the internal force, the obtained cross section area will also increase. If the main material is under stable control, then in the selection of the main material specifications, in addition to the internal force has a certain relationship with the bear, the length will also affect it, in the case of internal force to maintain a certain value, the length of the component and required specifications is proportional to the relationship. But in the case that the length remains unchanged, if the internal force continues to rise, then the familiar specifications will continue to expand. Thus, when the external load remains unchanged, the selection of section will be affected by the calculated length of the component, and the weight of the tower will also change directly.

The accumulated experience shows that the most appropriate calculation length of the main

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material is based on the strength and stability of the main material, which is also known as the critical length. In order to determine the length of the internode, the segmentation of the tower body, legs, dimensions and other factors will restrict it, and the influence of the length of the node on the auxiliary materials and inclined materials should also be considered. Based on the integration of previous design experience, this study puts forward the design results as shown in FIG. 3:

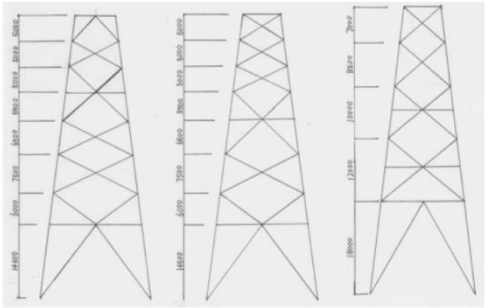

FIG. 3 Subsection comparison diagram of tower body

Combined with the above analysis, it can be seen that the number of nodes in the first and second schemes always remains the same without much difference. In the third scheme, large internode arrangement scheme is selected, and the specific impact is shown in Table 3:

Table 3 Material consumption comparison results of the three schemes

Internode combination scheme	1	2	3
Tower of heavy	140.5	144.7	150.3
Tower weight than	1	1.03	1.07

After comparing the optimized arrangement of nodes, it can be found that the structural layout is reasonable and the consumption of materials is the least, so that all components can be effectively connected.[10]

3.2 Tower separation surface

In the tower design, the staff should design the transverse surface of the tower body reasonably, so as to effectively enhance the torsional stiffness of the structure. The torsion force generated by the external load on the upper part of the structure will deal with the internal force of the structure in a balanced way. The load forces in the slope changing area of tower body are concentrated together, and a stress partition is set, which will form a representative partition form in the long run. According to the analysis of the technical regulations of tower structure design for overhead transmission line, the design interval of cross partition should be within five times of the average width under the condition that the slope of tower has not changed. According to the analysis of practical engineering design experience, it is necessary to rationalize the design of the partition, so as to ensure that there is no bulge phenomenon in the external dimension of the structure.

Conclusion

To sum up, there are still many problems in the structural design of transmission line towers in China, which will directly affect the stability and security of power grid system operation, and then threaten People's Daily life and work mode. Therefore, the designers of transmission line tower structure should combine with the actual situation, put forward scientific and reasonable measures, and accumulate experience according to practical research, so as to achieve the structure optimization design of the tower body, so that it can meet People's Daily power supply needs, so as to promote the steady development of the electric power industry. At the same time, it is necessary

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to strengthen the training of professional and technical personnel, and actively introduce advanced system management software platform, so as to improve the operation efficiency of transmission lines and create a safe and comfortable working environment.

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