Design of 110kV Overhead Power Transmission Line for River Crossing Tower in Flood Control Project (Zone 15)

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CONTENT

1 Project overview

1) Project name: Design of 110kV Overhead Power Transmission Line for River Crossing Tower in Flood Control Project (Zone 15)

2) The starting and ending point of the line: it starts from the newly built Tangzhuang 110kV substation and ends at the Dazhai 220kV substation.

3) Rated voltage: 110kV.

4) Number of circuit loops: single loop.

5) Conductor model: JL/G1A-300/25 steel core aluminum stranded wire.

6) Ground wire model: One side of the line is 48-core OPGW optical cable, and one side is JLB40-100 aluminum-clad steel strand.

7) Line length: The total length of the project line is 6.809km.

8) Neutral point grounding method: This project adopts the neutral point direct grounding method.

9) Divided into dirty area: Class E.

10) Topography along the line: The proposed construction site is located in Guangping County, Handan City, with G309 National Road in the north. The location of the proposed tower base is generally passed by rural roads, and the traffic conditions are relatively convenient. The landform type is alluvial-proluvial plain, the site is now cultivated land, and the terrain is flat. Considering the environment type II environment, the groundwater is slightly corrosive to the concrete structure; considering the low permeability of the stratum, the groundwater is slightly corrosive to the concrete structure. Under the condition of long-term immersion, groundwater is slightly corrosive to the steel bars in the reinforced concrete structure; under the condition of alternating dry and wet, the groundwater is slightly corrosive to the steel bars in the reinforced concrete structure. It is weakly corrosive; considering the low permeability of the stratum, the soil is slightly corrosive to the concrete

structure; the soil is slightly corrosive to the steel structure; the soil is weakly corrosive to the steel bars in the reinforced concrete structure.

12) Transposition of the ground wire: This line does not need to be transposed.

13) Forest felling and house demolition: Long-term residential buildings, factories, farms, etc. within 2m outside the line of the project will be demolished. The spanning and demolition of other buildings shall be designed in accordance with the "Code for Design of 110-750kV Overhead Transmission Lines". The tree species spanned by this line mainly include poplars, landscape trees, etc., which are considered according to the natural growth height of the trees. The cutting width of sporadic trees and row trees shall be considered within 10 meters outside the sideline.

2 Line Path

2.1 Line path

This line project starts from the newly built Tangzhuang 110kV substation and ends at Dazhai 220kV substation. This line is located in Guangping County, Handan City, with a total length of 6.809km and 9 turns.

The line starts from Tangzhuang 110kV substation, and runs westward parallel to the proposed Dazhai-Chengmeng T to the south side of the 110kV line of Tangzhuang substation. After the new single-circuit terminal tower is built, it goes south to the north of Xiaoweizhuang Village, then turns to the west, and then to the left. Turn to the southwest and cross the east branch of Wangfeng Main Canal to avoid the weather tower to the north of Tangzhuang Village, then turn right and continue westward through Lizhuang Village and Zhouguzhai Village, cross the west branch of Wangfeng Main Canal, turn left, and set up a two-base single-circuit drilling and crossing tower Drill across the 110kV front line (between N5-N6 towers), then turn right and go west along the south side of the 110kV front line, and use the cross arm on the north side of the terminal tower of the Dazhai-Yangqiao 110kV line to connect to the Dazhai substation. A 110kV line from Dazhai to Tangzhuang is formed.

2.2 Substation Outgoing Line

Dazhai 220kV substation is located in the east of Houdazhai Village, Guangping County, west of 1.8km south of the intersection of National Highway 309 and Daya Line. 110kV outgoing lines are planned to go out 12 times to the east, from south to north are Zhaichang and Dazhai T connections, Guangping, Gaoqu I-Guangping T connections, Shengying-Daigu T connections, Yangqiao and Yuanzhai T connections , reserved, Qianning and Zhangdong T connection, Changzhuang traction, Chengmeng, Anzhai, Songzhai and Nanzhongbao T Zhaigu, Yizhuang. This project occupies the seventh outlet interval from the north.

Tangzhuang 110kV substation site is located in the west of Jiangzhuang Village, Nanhan Village Township, Guangping County, north of Xiaoweizhuang Village, 800 meters west of the intersection of National Highway 309 and Deqingyuan Avenue. 110kV is planned to go out three times to the west. This project occupies the third outgoing interval from the north. The outgoing lines of Tangzhuang 110kV substation from north to south are reserved, 110kV Dameng T connection, and Dazhai.

2.3 Design meteorological conditions

The operating experience of the existing lines in the area where the line is located and the relevant regulations of the "Code for Design of 110kV ~ 750kV Overhead Transmission Lines", in line with the requirements of the regulations that the values listed in the typical meteorological region are generally used when they are close to the typical meteorological region, the calculation of the meteorological conditions is listed. as follows:

Weather condition		Temperature (℃)	Wind speed (m/s)	Ice thickness (mm)
Maximum temperature		40	0	0
Minimum temperature		-20	0	0
Atmospheric	wind	15	10	0

Weather condition		Temperature (℃)	Wind speed (m/s)	Ice thickness (mm)
over voltage	no wind	15	0	0
Basic wind speed		-5	25	0
The annual average temperature		15	0	0
Icing		-5	10	5
Operating over-voltage		15	15	0
Installation		-10	10	0
Live work		15	10	0
Average annual number of thunderstorm days		30days		

3 Wires and Ground

3.1 Wires

According to the information provided by the access system design, the conductor of this project adopts a conductor with a nominal cross-section of 300mm^2. In view of the fact that most of the areas covered by this project are located in the plain area, the JL/G1A-300/25 steel core aluminum stranded wire in the State Grid ERP material procurement standard is selected.

List of mechanical and physical parameters of JL/G1A-300/25 steel core aluminum stranded wire

Project	JL/G1A-300/25
Aluminum strand×diameter+steel strand×diameter	48/2.85+7/2.22
Steel section（mm^2）	27.10
Aluminum Section（mm^2）	306.21
Aluminum-steel section ratio	11.3
Overall section （mm^2）	333.31
Outer diameter（mm）	23.8
Elasticity coefficient（N/mm^2）	65000

Linear expansion coefficient（N/mm^2）	20.5×10-6
Calculate the breaking force（N）	≥83760
Maximum use tension（N）	33504
Maximum working stress（N/ mm2）	100.5
Calculated weight（kg/km）	1057.0
Safety factor	2.5

The maximum operating stress of the wire is determined: according to "Aluminum Stranded Wire and Steel Core Aluminum Stranded Wire", the test ensures that the breaking force is not less than 95% of the calculated breaking force, the safety factor is 2.5, and the maximum design stress is 95.49N/mm2. The annual average operating stress is 59.68N/mm2, which is 25% of the failure stress of the wire. The influence of the plastic elongation of the wire on the sag is handled by the cooling method. When the wire is installed, reduce the temperature by 25° C to compensate for the influence of the initial elongation on the sag.

Ice-covered and galloping conductors will damage transmission line towers, fittings, conductors, and ground wires, and even cause line faults to trip in severe cases. In order to effectively strengthen the actual effect of anti-dancing measures, reduce the trip rate of transmission lines, and ensure the safe and stable operation of the power grid, according to the "Design Specifications for Anti-dancing of Overhead Transmission Lines" and "Dancing Distribution Map of Southern Hebei Power Grid", this project is at level 2 dancing risk. In the area, the anti-galling measures adopted are the design of reinforced jumper fittings, the tension tower, the straight tower adjacent to the tension tower, the whole tower adopts double-cap anti-loosening bolts, and the nut adopts post-plating tapping technology to reduce the gap between the bolt and the nut. fit clearance. The design of reinforced jumper fittings is adopted, and anti-dancing measures such as double-nut anti-loosening bolts are adopted for the entire tension tower of the whole line.

Distribution map of galloping power grid in southern Hebei

3.2 Ground wire

In this project, a 48-core OPGW optical cable is erected, and the other is a JLB40-100 aluminum-clad steel strand. OPGW parameters are to be provided by the manufacturer.

JLB40-100 shunt line mechanical and physical parameters table

Ground wire model	JLB40-100
Number of strands/diameter per share(mm)	19/2.6
Overall section(mm^2)	100.88
outer diameter(mm)	13
unit weight(kg/km)	474.6
Calculate the breaking force(kN)	≥61.74
0.3s allowable short-circuit current, kA (short-circuit initial temperature 40 degrees)	17-20
Elasticity coefficient(kN/mm^2)	109
Linear expansion coefficient(1/°C E-6)	15.5

3.3 Anti-vibration for conductors and ground wires

According to the requirements of "Code for Design of Overhead Transmission Lines from 110kV to 750kV", the conductor and ground wires are equipped with anti-vibration hammers as anti-vibration measures. Conductor JL/G1A-300/25 steel core aluminum stranded wire adopts FDY-3/5 anti-vibration hammer, and ground wire JLB40-100 aluminum clad steel wire adopts FDR-1/2 hammer.

The configuration of the anti-vibration hammer is shown in the following table:

Anti-vibration hammer model	Number of anti-vibration hammers		
	1	2	3
FDY-3/5	a≤450	450< a <800	800≤a <1200
FDR-1/2	a≤350	350< a <700	700≤a <1000
（OPGW）	a≤250	250≤a <500	500≤a <750

The creep elongation effect should be taken into consideration when the continuous gear is erected. The creep elongation is treated by the cooling method, the temperature of the wire is lowered by 25°C, and the temperature of the JLB40-100 good conductor ground wire is lowered by 15°C.

When the wire feeder and N21~N22 are wired during construction, the effect of creep elongation is not considered. Length requirements for over-traction: 0.2m for wire and 0.1m for ground wire.

4 Insulation coordination

4.1 Air gap

The altitude of this line is between 40 and 50m. According to the national standard "Code for Design of Overvoltage Protection and Insulation Coordination of AC Electrical Installations", the following values are used for the insulator strings and air gaps of overhead transmission lines in areas where the altitude does not exceed 1000m: The frequency and voltage gap is 0.25 m; the operating overvoltage gap is 0.70 m; the lightning overvoltage gap is 1.00 m; the combined meteorological conditions for live work are 15 degrees and the wind speed is 10 m/s. The verification gap between the live part and the grounding part of the tower shall not be less than 1m.

4.2 Insulation coordination and insulator selection

The insulation design of this project is carried out in accordance with the "Distribution Map of Polluted Areas of Hebei South Power Network" issued by Hebei Electric Power Company and in accordance with the provisions of "Environmental Pollution Classification of High Voltage Overhead Lines, Power Plants, and Substations and Selection Standards for External Insulation". According to the "Distribution Map of Polluted Areas of Hebei South Network", the line of this project is located in the d and e-level pollution areas. According to the on-site investigation, the main pollution sources along the line are automobile exhaust, industrial dust, etc., and the line is determined to be the e-level pollution area. According to the preliminary design review Opinion, the insulation of the whole line is configured according to the E-level pollution area. Both the hanging string and the tensile string are made of synthetic insulator FXBW-110/120-3.

The tensile insulator string adopts duplex FXBW-110/120-3 composite insulators with a creepage distance of 3520mm and a uniform creepage ratio of 57 mm/kV. The wire suspension insulator string adopts FXBW-110/120-3 composite insulator, its creepage distance is 3520mm, and the uniform creepage distance is 57 mm/kV. FXBW-110/120-3 composite insulators are used for the dangling insulator strings of wires in the e-class pollution area, with a creepage distance of 3520mm and a uniform creepage ratio of 57 mm/kV.

The synthetic insulator used in this project adopts the structure of large and small umbrellas, and the ratio of the distance between the umbrella and the length of the shed should not be less than 0.8. The top sheet of FXBW-110/120-3 synthetic insulators used for pendant strings (including jumper strings) should be of large diameter (anti-ice flash and bird damage, etc.). A pressure equalizing ring is installed at the lower end of the synthetic insulator, a good sealing ring should be installed at the connection part between the fittings and the mandrel, and the mandrel should be an acid-resistant type.

The technical characteristics of insulators are listed in the following table:

serial number	Insulator code	FXBW-110/120-3
1	Rated voltage(kV)	110
2	Rated mechanical load (kV)	120
3	Structure length L(mm)	1440
4	Minimum arc distance(mm)	＞1000
5	Creepage distance(mm)	≥3520
6	Lightning impulse dry withstand voltage(kV)	≥550
7	Power frequency wet withstand voltage(kV)	≥250

4.3 Lightning protection and grounding

The annual number of lightning days in the area where the line of this project passes is 30 days/year. In order to prevent lightning from directly hitting the conductors, two ground wires are erected throughout the line. The protection angle is less than 15^{o}. The clearance distance between the conductor and the lightning conductor meets the requirement of 0.012L+1m in the case of atmospheric overvoltage and no wind (L is the span). The distance between the two lightning conductors on the tower should not exceed 5 times the vertical distance between the lightning conductor and the conductor.

The project is designed according to the non-residential area. The grounding device of the iron tower adopts the square ring and radiation type (the square ring grounding device can meet the requirements without adding radiation). The material of the grounding device is Φ12 galvanized round steel, and the buried depth is 0.8m. The towers of the whole project are grounded base-by-base and leg-by-leg, and corresponding grounding devices are respectively configured for different soil resistivities. The power frequency grounding resistance of the iron tower shall not exceed the values listed in the following table when it is dry in the thunderstorm season:

Soil resistance	≤100	100～500	500～1000	1000～2000
Power frequency grounding resistance	10	15	20	25

5 Pole Tower

5.1 Finite element model of three towers and two lines

When using ANSYS finite element software to model transmission lines, the models are mainly divided into three types: truss model, rigid frame model and hybrid model. The truss models are all modeled by rod elements, the nodes are regarded as hinges, and the overall stiffness of the model is lower than the actual stiffness. The steel frame models all use beam elements, and the nodes are rigidly connected. In engineering practice, it is generally believed that the auxiliary materials in the tower structure only bear the axial force and do not bear the bending moment, so the definition of the auxiliary materials as beam elements does not match the actual situation. .

This study intends to use the truss-girder hybrid model to establish a three-dimensional model of the tower-wire system of the transmission tower, conductor and ground wire. The main material, the diaphragm and the inclined material with auxiliary materials are defined as space beam elements, and the common inclined material and auxiliary materials are defined as rod elements. Among them, the beam element is simulated by the BEAM188 element in ANSYS, the rod element is simulated by the LINK180 element, and the constitutive relationship of the steel is selected from the bi-fold line elastic-plastic model. The ground wire is a flexible suspension cable system, and the LINK10 unit is used for simulation. On the basis of assuming that the ground wire only bears the tensile force, the ground wire is modeled according to the catenary equation. The insulator is modeled with a rod element, one end is hinged to the guide (ground) wire, and the other end is hinged to the cross arm of the transmission tower or the ground wire support. The finite element model is shown in the figure below.

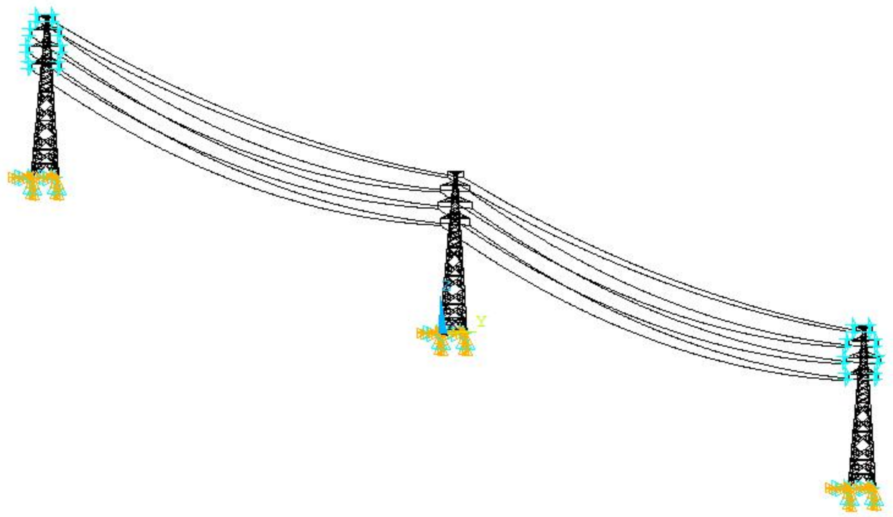


Figure 5-1 Finite element model of tower-line coupling system

5.2 Single tower modal analysis

Modal analysis is an effective way to determine the inherent vibration characteristics of a structure. The mode is the proportional relationship of the displacement of each point on the structure deviating from the equilibrium position when the structure vibrates according to a certain order natural frequency. Modal analysis is the premise and foundation of studying the dynamic characteristics of the structure. Its purpose is to obtain the natural frequency and mode shape of the structure, which are the inherent characteristics of the structure and are determined by the structure itself. In addition, modal analysis can verify the rationality of the finite element model.

Considering that the transmission tower is a structure with high flexibility and small deformation, the modal analysis only extracts the natural frequency and mode shape of its low-order mode. On the basis of considering the orientation of the main material of the transmission tower and the angle steel of the diaphragm, the mode of the finite element model of the single tower is analyzed, and the first three vibration modes are extracted as shown in Figure 5-2.

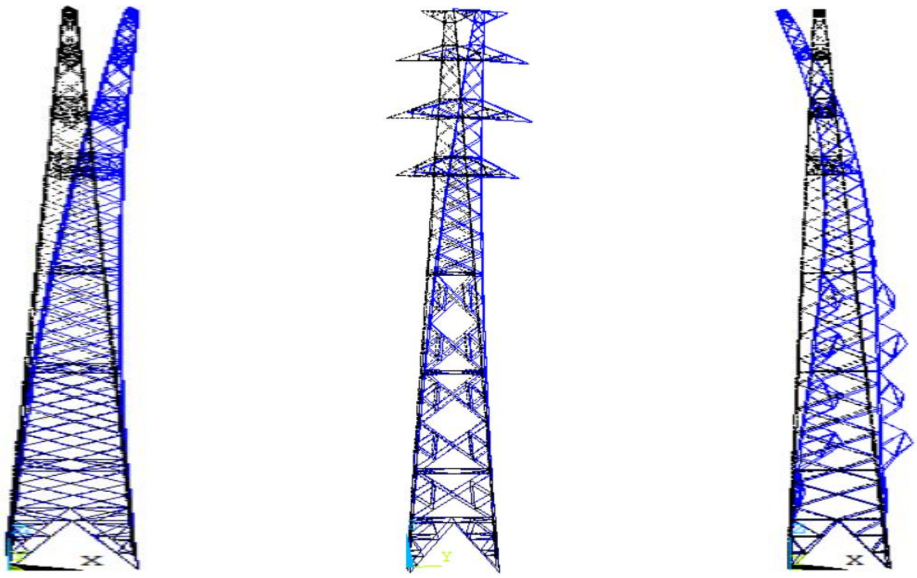


Figure 5-2 The first 3 vibration modes of the transmission tower extracted by ANSYS

5.3 Internal force calculation of tower structure

The tower structure design adopts the limit state design method based on probability theory. The limit state of the structure refers to the safety of the line under the specified combination of loads or under the limit conditions of various deformations or cracks. Critical state. The limit state is divided into the limit state of bearing capacity and the limit state of normal service.

1) Limit state of bearing capacity

The strength, stability and connection strength of structures or components shall be combined according to the requirements of the ultimate state of bearing capacity and the basic combination of load effects, and shall be designed using the following design expressions:

$$\gamma_0\left(\gamma_G \cdot S_{GK} + \psi \cdot \gamma_Q \cdot \sum S_{QiK}\right) \leq R$$

In the formula, γ_0 is the importance coefficient of the tower structure, the important line should not be less than 1.1, the temporary line is 0.9, and the other lines are 1.0; γ_G is the permanent load sub-item coefficient, which is not more than 1.0 when it is favorable for the structural force, and 1.2 when it is unfavorable. ; Take 0.9 when checking the anti-overturning or anti-slip of the structure; γ_Q is the sub-item coefficient of the variable load, and 1.4 gua. S_{GK} is the standard value of the permanent load effect; S_{QiK} is the representative value of the i-th variable load effect; Ψ is the The variable load adjustment factor is 1.0 for normal operation, design icing, and low temperature, and 0.9 for disconnection, installation, and uneven icing; *R* is the design value of structural member resistance.

2) Normal use limit state

For deformation or cracks of structures or components, standard combinations of loads shall be adopted in accordance with the requirements of the normal service limit state.

$$S_{GK} + \psi \sum S_{QiK} \leq C$$

In the formula, C is the specified limit for the structure or component to meet the normal use requirements, such as tower deformation, foundation cracks, etc.

This project uses Smart Tower software to calculate the internal force, check the stress ratio of the tower. The following figures are the stress ratio cloud diagrams of the towers of 1A3-SJ1, 1A3-SZ1, and 1A3-SZK, respectively.

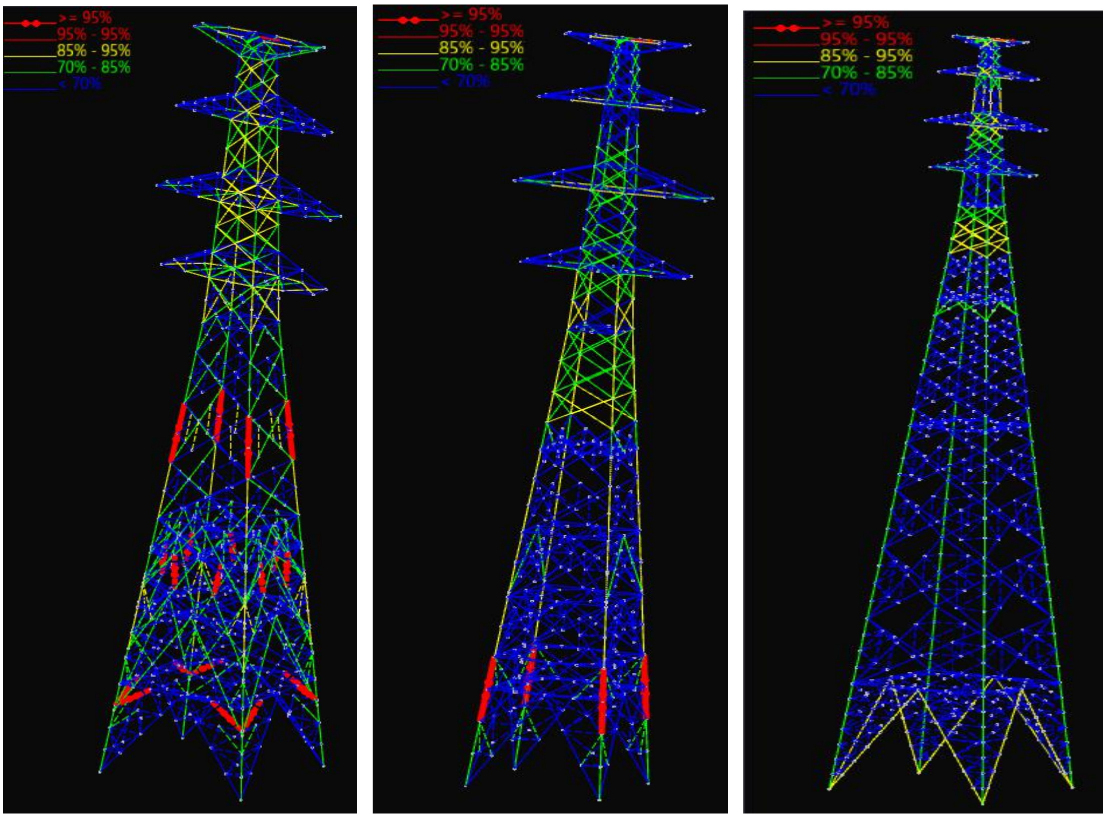


Figure 5-3 The tower stress ratio cloud diagram of 1A3-SJ1, 1A3-SZ1, 1A3-SZK

5.4 Pole tower processing and construction requirements

The processing of the iron tower shall comply with the provisions of the "Technical Conditions for the Manufacturing of Transmission Line Towers". Steel and welding rods used for iron tower processing must meet the technical requirements of the current national standards. For each batch of materials, in addition to the manufacturer's technical documents, the chemical composition, physical and mechanical properties and section size should also be sampled. When making holes for iron tower components, punching technology can generally be used. However, when the thickness of material Q235 is 16 mm and above, and the thickness of material Q355 (Q345) is 14 mm and above, the hole must be drilled or punched first with a small hole smaller than the specified diameter of 3 mm, and then drilled and expanded to the specified size. Aperture. The distance between the guide and ground wire hanging plates or the hanging angle steel is the key to ensure the flexible rotation of the guide and ground wire hanging hardware. It must be ensured that there is no negative error in the distance during processing, and the positive error should not be greater than 2mm. Before the iron tower leaves the factory, it must be tested on a base-by-base basis. The surrounding of the tower foot plate should be flat, smooth, free of burrs and cracks. The inclination angle of the shoe plate on the tower foot plate should ensure its accuracy, and there should be no gap when connecting with the main material and inclined material of the tower body. When making holes for the foot bolt holes on the tower foot plate, the holes should be led first, and the hole diameters specified in the design should be reached successively. The tower foot plate should be flat after correction, and there should be no unevenness, so as to affect the connection with the foundation.

The order of the tower must be based on the number of tower types after re-testing and adjustment. The iron tower should be processed and transported according to the current transmission line tower manufacturing standards and design requirements. The iron tower components may wear zinc skin during transportation and installation, forming a weak link in anti-corrosion. Corrosion should also be dealt with in a timely manner. After the whole tower is processed, trial assembly must be carried out before mass production. Steel and tower components that do not meet the quality requirements shall not be used. The tower construction and acceptance shall be implemented in accordance with the "Code for Construction and Acceptance of 110-750kV Overhead Transmission Lines". When the tower is assembled, if it is found that the bending deformation of the tower components exceeds the specification requirements, it must be straightened or replaced. The steel towers of the whole line are made of Q355B (Q345B) and Q235B. If other varieties and specifications need to be used instead due to special circumstances, design opinions must be obtained in writing, and the design representatives will check and review according to the specifications and varieties to be used. It can be used as a substitute after consent. The overall vertical tower should be carefully selected to prevent the tower from being damaged or deformed during the lifting process. For towers connected with anchor bolts, protective caps should be poured as soon as possible to prevent tower collapse accidents due to theft of nuts. The installation sequence of all tower conductors in this project must be carried out from top to bottom. For all towers, double lifting should be avoided as much as possible when installing guide and ground wires.

After the guide and ground wires are over-tracted, the speed should be slowed down when the wires are loosened to reduce the impact on the tower. All straight-line towers can perform anchor line operations, and the angle between the anchor line and the ground shall not be greater than 20 degrees. The additional load of the installation wire shall not exceed 3.5kN, and the additional load of the installation ground wire shall not exceed 2KN. When installing a tension-resistant tower, a temporary cable must be installed. The angle between the temporary cable and the ground should not be greater than 45 degrees. The additional load of the installation wire shall not exceed 4.5kN, and the additional load of the installation ground wire shall not exceed 2KN. When tightening the line, the angle between the tightening rope and the ground should not be greater than 20 degrees. For the corner towers and terminal towers with a turning angle greater than 30 degrees, two pulleys must be used when the tension is paid off, and they are placed on the front and rear sides of the cross arm to reduce the local force on the cross arm. At the same time, the pulley should be checked according to the wiring construction plan The strength of the connection to the tower. Before construction, you should be familiar with the design and installation conditions of various types of towers, and assemble, erect and wire according to the design and installation conditions. The bolt tightening torque should not be less than the stipulations in the "Code for Construction and Acceptance of 110-750kV Overhead Transmission Lines". For bolts greater than or equal to 6.8, refer to Article 6.1.6 and the description of the code. The tower bolts should be re-tightened before and after the dancing season. After the line is put into operation, in order to maintain the stability and safety of the line and the tower base, it is strictly forbidden to take soil near the tower, stack crops on the tower, and hang anything around the tower. In this project, anti-dance design is added, and structural measures are adopted at the connection between the cross arm of the tension tower and the tower body to improve the out-of-plane stiffness of the joint. The upper plane of the conductor cross arm of the tension tower and the web bar of the lower plane of the ground wire support are arranged to form a stable support system. The tension tower with anti-dancing requirements and the adjacent straight tower above 8 meters are all designed with double caps. The bolts shall be anti-dancing, and the bolts above 8 meters in the tower position without anti-dancing requirements shall be constructed according to the drawings.

6 Basics

6.1 Geological conditions

The proposed site is located in Guangping County, Handan City, with G309 National Road in the north. The location of the proposed tower base generally has rural roads passing through it, and the traffic conditions are relatively convenient. The landform type is alluvial-proluvial plain, the site is now cultivated land, and the terrain is flat. The proposed site has a single landform, no adverse geological effects are found, and the building suitability is relatively suitable. No buried objects such as river channels, tombs, air-raid shelters, etc., which are unfavorable to the project, were found within the survey depth and scope of the site. The foundation of the proposed building (structure) shall be a uniform foundation. The proposed construction site is a general area for building earthquake resistance, and the site is basically stable. The seismic fortification intensity is 7 degrees, the design basic seismic acceleration is 0.10g, and the design earthquake to which it belongs is grouped into the second group. Building site category III, the characteristic period is 0.55s; according to the "China Earthquake Parameter Zoning Map", the peak acceleration of the site ground motion is 0.125g, and the characteristic period is 0.65s. Considering the environment type II environment, the groundwater is slightly corrosive to the concrete structure; considering the low permeability of the stratum, the groundwater is slightly corrosive to the concrete structure.

Under the condition of long-term immersion, groundwater is slightly corrosive to the steel bars in the reinforced concrete structure; under the condition of alternating dry and wet, the groundwater is weakly corrosive to the steel bars in the reinforced concrete structure. Considering the environment type II environment, the soil is weakly corrosive to the concrete structure; considering the low permeability of the stratum, the soil is slightly corrosive to the concrete structure; the soil is slightly corrosive to the steel structure; the soil is slightly corrosive to the reinforced concrete structure. The steel bar is weakly corrosive. The standard freezing depth of the site is 0.60m. The site soil does not liquefy. The proposed site can be fortified according to the general area.

6.2 Basic type design

In order to simplify the model and facilitate the calculation, the following basic assumptions will be adopted in this basic numerical analysis and simulation of seasonally frozen soil: ignore the impact on the soil around the foundation due to the excavation and landfill of the foundation pit, and at the same time the foundation The presence of parameters on seasonally frozen soil has no effect. The friction coefficient of the contact surface between the foundation and the soil remains unchanged during the modeling process. A contact pair is set for the contact between the foundation and the soil, wherein the contact surface on the foundation is the main contact surface, and the contact surface on the soil body is the secondary contact surface. In the process of analyzing the force of the foundation, the foundation will not be damaged, and the soil will undergo displacement and deformation due to the load, resulting in plastic failure. The foundation is an isotropic mean linear elastic material, the soil is an isotropic homogeneous elastic-plastic material, and the stress and failure of the soil obey the Mohr-Coulomb yield criterion.

According to the engineering design data given by the design institute, the straight column expansion plate foundation and the conical column expansion plate foundation to be selected for this tower location, through ABAQUS/CAE to establish the straight column expansion plate foundation and the tapered column expansion plate foundation model prototype, using Conical column foundation with a slope of 9°.

Figure 6-1 Straight column expansion board

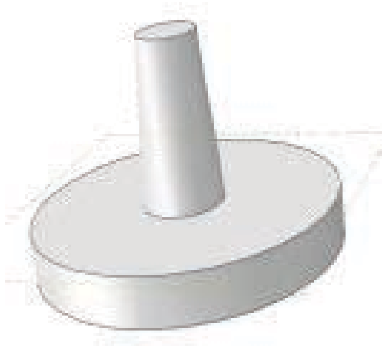


Figure 6-2 Taper column expansion board

In ABAQUS, the interaction between pile foundation and soil is usually modeled by defining friction, and contact problems are handled by contact surface or contact element simulation.

According to the characteristics of the model, this paper selects the surface-to-surface contact among the contact types. Therefore, first of all, it is necessary to determine the master surface and the slave surface according to the stiffness of the contacting object. In this subject, the foundation is a concrete material, and its stiffness is obviously greater than that of the soil. Therefore, the foundation is the main surface and the soil is the secondary surface. For the relative displacement between the simulated soil and the foundation, select the slip type as limited slip.

Abaqus provides two formulations of mechanical constraints, including kinematic contact and penalty function contact. Kinematic contact does not apply to rigid-body-to-rigid contact, it applies to contact-to-contact. The penalty function is suitable for the contact between the self-contact and the rigid body, so this simulation adopts the penalty friction contact, and the friction coefficient is taken as 0.5.

According to the actual size of the model, the basic solid model and the soil solid model are established in a 1:1 ratio. C3D8R eight-node linear hexahedral element is used to mesh the model. First, the mesh is seeded, and then the foundation and soil model are divided into regular components from the inside to the outside by sweeping. The meshing effect is shown in Figure 6- 3.

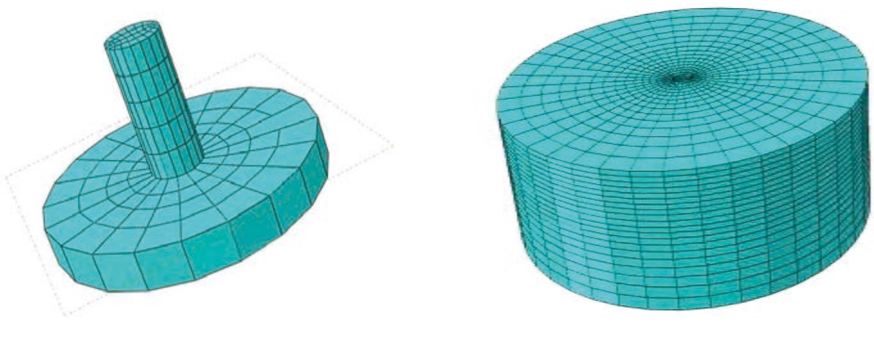


Figure 6-3 Meshing

The reason for the deformation and displacement of the soil is that the stress on the foundation is transmitted and dispersed around. Therefore, the farther the soil is from the foundation, the smaller the displacement will be, and the stress and strain in the soil will also increase accordingly. Small. After the trial calculation of the model, it is determined that the soil depth is taken as 10m and the radius is taken as 10m. The figure below is the displacement cloud map of the foundation when the model is subjected to the uplift force on the soil. It can be seen that the maximum displacement of the foundation lies in the foundation and the soil around the foundation, while the displacement of the outer boundary of the soil is very small, almost zero. It can be seen that the selected computational domain meets the requirements.

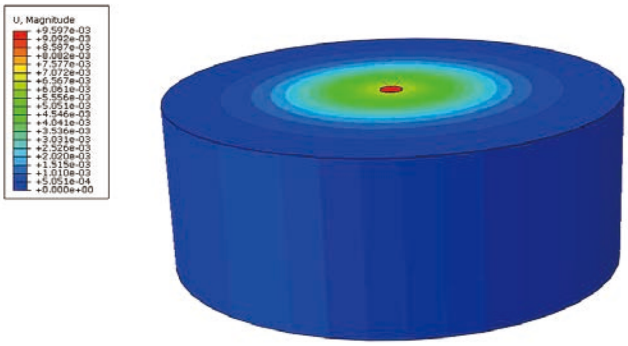


Figure 6-4 Displacement cloud map

In the process of numerical simulation, the size of the model is generally established according to the size of the actual project. However, in the actual situation, the natural shape of the soil is formed after the deformation caused by the self-weight of the soil, and the corresponding internal force in the soil is formed. is the initial ground stress. If the in-situ stress balance is not performed on the soil model first, the model will be greatly different from the actual stress after the external load is applied, which will lead to errors in the simulation. Therefore, only after the in-situ stress balance is carried out, the soil model can meet the requirements of in-situ stress balance, which can meet the actual engineering.

In ABAQUS, the soil model is calculated by loading the same gravity and boundary conditions as the actual situation. After the calculation is completed, the internal force generated after deformation is applied to the model to approximate the actual in-situ stress. The same gravity and boundary conditions are then applied again to complete the in-situ stress balance. Further load simulations and calculations can only be carried out on the basis of in-situ stress balance. First, apply gravity to the entire soil body, and then start the analysis step of balanced in-situ stress. After calculation and analysis, the vertical displacement of the soil after the equilibrium in-situ stress is shown as follows.

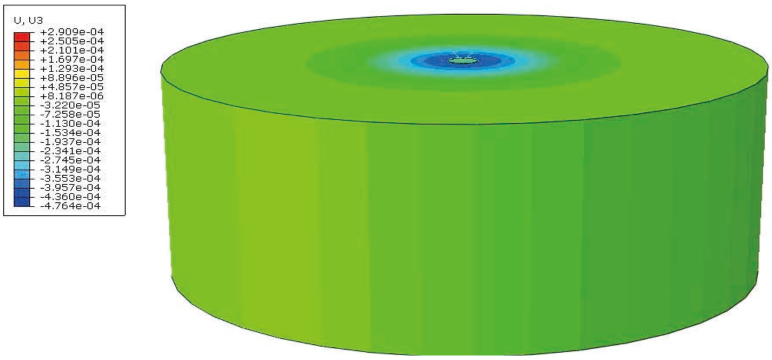


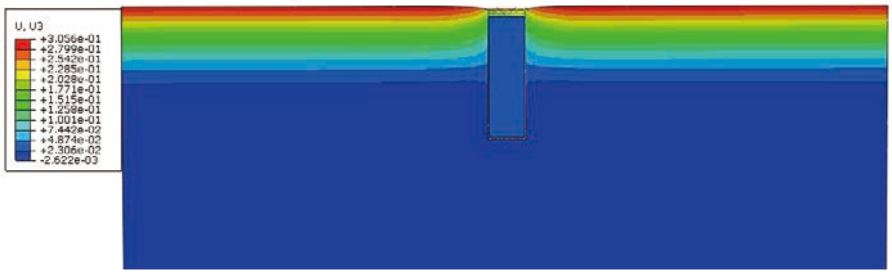
Figure 6-5 Vertical displacement of soil after balancing in-situ stress

Figure 6-6 Vertical stress of soil after equilibrium in-situ stress

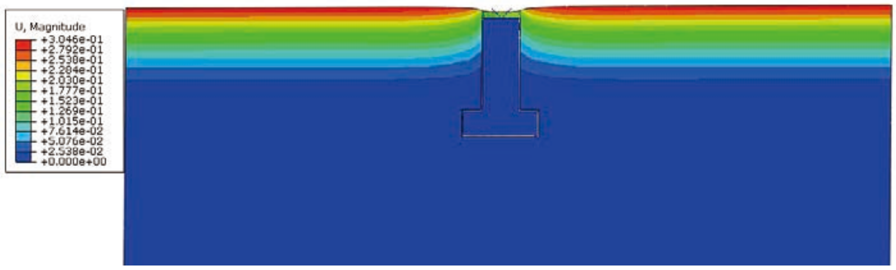
6.3 Foundation stability analysis

During foundation construction, especially in the rainy season, the descending, drainage and support work should be done well to avoid the occurrence of quicksand, piping and other phenomena, resolutely prevent pit wall slippage, collapse and other problems, and should pay attention to avoid disturbing the foundation soil at the bottom of the pit. When backfilling the foundation groove, the soil material with large viscosity, large anti-pulling angle and stable properties should be selected as far as possible. The backfilling of the foundation pit shall be carried out in strict accordance with the "Code for Construction and Acceptance of 110-750kV Overhead Transmission Lines". It is strictly forbidden to backfill with silt soft plastic soil. Before foundation construction, the foundation construction drawings and tower structure drawings should be carefully checked, and the foundation heel opening and the small heel opening of the foot bolts should be checked.

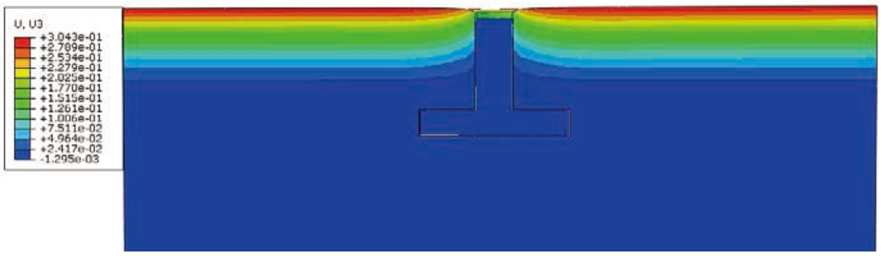
Through the finite element calculation of the effect of the temperature displacement coupling field on the vertical column foundations of different sizes, the displacement cloud diagram of the foundation of each size is extracted, and the vertical displacement cloud diagram is as follows:



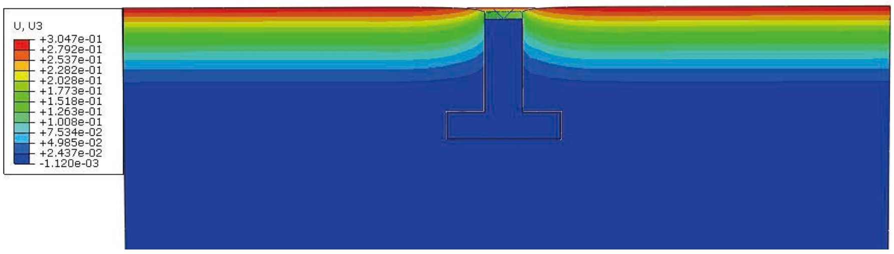
a) Vertical displacement cloud diagram of vertical column foundation 1



b) Vertical displacement cloud map of vertical column foundation 2



c) Vertical displacement cloud map of vertical column foundation 3



d) Vertical displacement cloud map of vertical column foundation 4

Figure 6-7 Vertical displacement cloud diagram of straight column expansion plate foundation

7 3D Design

3D design technology is to use 3D model as an information carrier, through structured data information, to provide a basis for information query, application and display. In the process of 3D design, by studying the depth and standards of modeling, it can promote the application of 3D models of power grids in the fields of power grid planning, design, construction, operation and management, promote the standardization of 3D models of power grids, realize model sharing, and meet the needs of the State Grid The requirements of "one issue and three receipts" provide a foundation for the establishment of engineering data centers.

7.1 Modeling of all-path ground objects

The modeling of the whole line path features includes: modeling of houses, trees, railways, highways, rivers, tombs, power lines, communication lines, etc.

Figure 7-1 Modeling of all-path ground objects

7.2 Modeling of conductors and fittings

The modeling content includes ground wire (including OPGW), ADSS model includes wire, ground wire, OPGW, ADSS, etc. Both the general model and the product model are described by parametric, and the split wire should be modeled separately for each wire; the online accessories include spacer bars, anti-vibration hammers, etc., which are constructed by graphical modeling. The three-dimensional model of the hardware insulator is based on the whole string, and the composition of the hardware string and the logical relationship of the hardware parts are described by parameterization, and the three-dimensional model of the hardware string is automatically generated according to the description. Contains basic information such as string type, string weight, and string length, and is used for insulation coordination, tower planning, and statistical engineering.

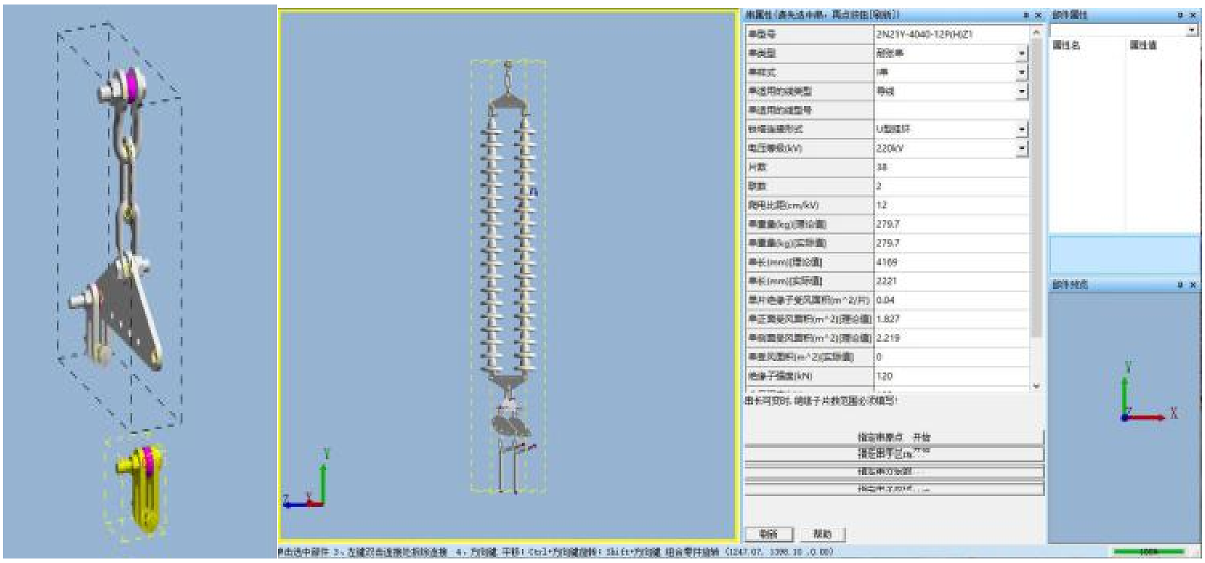


Figure 7-2 3D model of assembled fittings insulator string

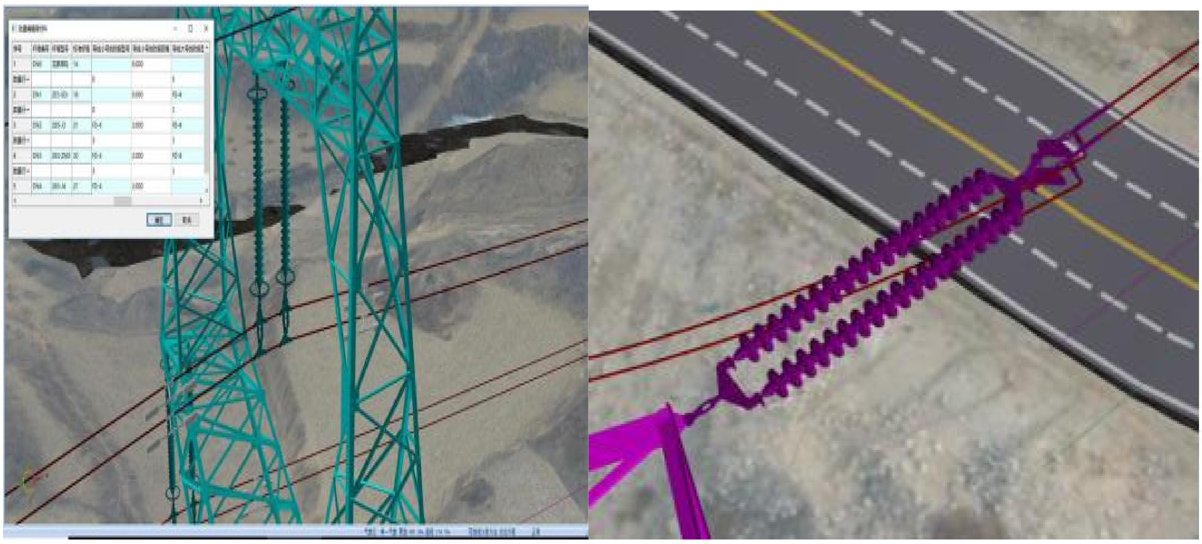


Figure 7-3 Connection between tensile string and tower

7.3 Basic Modeling

Based on parametric modeling, a three-dimensional product model is established. The foundation model includes the outline of the foundation and the model of the connection part with the tower foot.

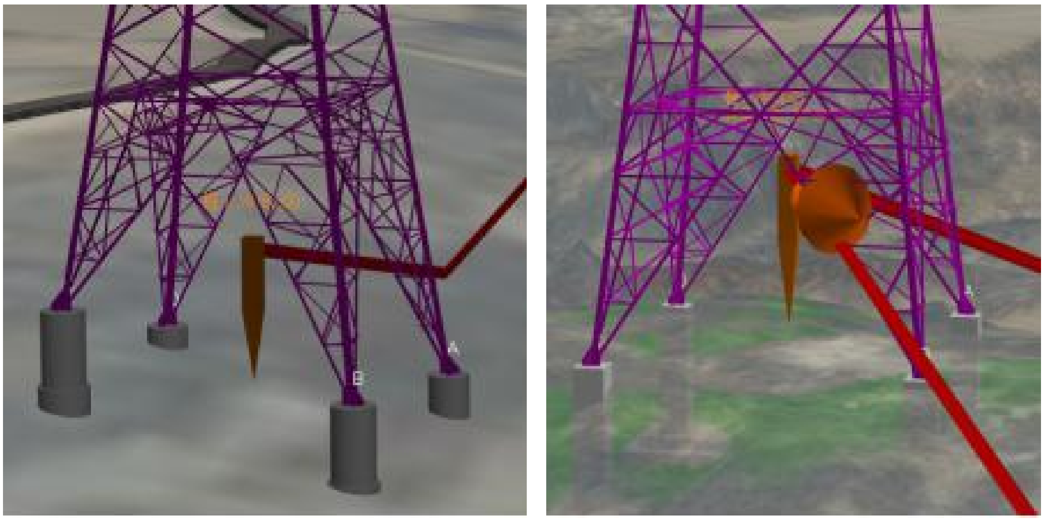


Figure 7-4 Basic connection

8 Design basis

(1) General design of power transmission and transformation project of State Grid Corporation of China

(2) "State Grid Corporation of the Power Transmission and Transformation Engineering Construction Drawing Design Content Depth Regulations Part 4: 110 (66) kV Overhead Transmission Lines"

(3) "Code for Anti-Dance Design of Overhead Transmission Lines"

(4) "Code for Design of 110kV ~ 750kV Overhead Transmission Lines"

(5) "Code for Design of Overvoltage Protection and Insulation Coordination of AC Electrical Installations"

(6) "Grounding of AC Electrical Installations"

(7) "Cable Line Construction and Acceptance Standards for Electrical Installation Engineering"

(8) "Code for Construction and Acceptance of 110-750kV Overhead Transmission Lines"

(9) "Design Regulations for the Protection of Transmission Lines from Dangerous and Interference Effects of Telecommunication Lines"

(10) "Technical Specifications for Basic Design of Overhead Transmission Lines"

(11) Regulations and specifications related to engineering design such as "Code for Design of Building Foundation", relevant national laws and regulations

(12) "Management Regulations for the Implementation of Mandatory Provisions of Power Transmission and Transformation Engineering Construction Standards Part 6: Engineering Design of Transmission Lines"