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A review of the force performance of multi-ring plate nodes of power transmission steel pipe towers

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Abstract: The research on the ring-type ribbed plate node used in the transmission steel pipe tower has been lagging. The influence of the multi-ring plate on the node bearing capacity has never been considered in the design process. The Chinese specification has not yet had a straightforward calculation method. This paper provides an overview of the stress performance of transmission steel pipe towers.
Keywords: Steel Pipe Tower; Multi-Ring Plate Node; Stress Performance; Bearing Capacity

1. Introduction

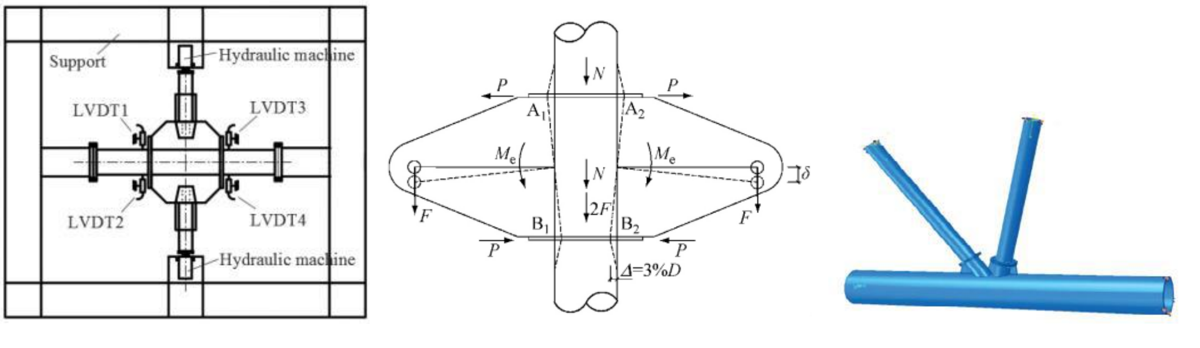
In recent years, steel pipe towers have been widely used in China's sizeable spanning line project and double (multi) return line with the same tower. Node is an integral part of the steel pipe tower. Its connection structure and bearing capacity are related to the safety of the whole building and even the entire line project. The node structure of the transmission tower is an essential part of tower design.

Guo Shaozong [1] made a summary of the development of transmission line towers at home and abroad. The transmission tower can be divided into self-supporting tower type, tie- line tower type, and extensive spanning building according to the characteristics of the force; most of the materials used in the tower are Q235 steel and 16Mu steel, and the bolts are rough bolts; the calculation of the tower includes the load treatment, the analysis of the internal force, and the design of the components. Fu Chunheng [2] summarized the current status of the use of large loads, the new structure of the tower type, and selection of factors affecting the new tower type is divided into multi-circuit towers and compact towers, multi-circuit towers are divided into angle steel towers, steel pipe towers, and narrow-base towers, the general 220kV double-circuit and 110kV double-back same tower and four-circuit circuit tower design, the use of steel pipe towers in the case of high external load ratings, the space constraints to choose a narrow-base tower, the compact tower is divided into single-circuit compact towers and double- circuit compact towers. Liao Zonggao [3] and others discussed the design of power transmission steel pipe tower-related issues, from welding, impact toughness, and strength to consider the selection of steel pipe tower materials, node strength calculation is a non-negligible problem, steel pipe coherent connection using weld type connection, coherent node weld needs to comply with the second level of quality standards for the appearance of the nodes, the bolts used in the tower to have corrosion-resistant requirements, the use of hot-dip galvanizing in the form of a steel pipe tower diagonal material and the primary material more than the use of the plate connection, the steel pipe tower and the base of the use of the foundation bolts to the ground connection. Hu Xing [4] and others studied the calculation model of transmission towers and analyzed the force and deformation characteristics by comparing the finite element models with different cell types for angle steel towers and steel pipe towers under common high wind conditions. Shen Guohui [5] and others have studied and analyzed the development status of large-span transmission towers. The primary forms of large-span transmission towers are divided into reinforced concrete towers, angle steel towers, steel pipe towers, and steel-hybrid structural combination towers. Wind load, seismic load, ice-covered deglaciation load, and disconnection impact load play a significant role in controlling the transmission towers, and the construction technology of the large span transmission towers includes component lifting, aerial work wind load, and conductor erection. This paper provides an overview of the compression, bending, and hysteresis properties of transmission towers.

2. Stress performance of ring plate nodes of power transmission steel pipe towers

Bao [6], Li Xiaolu [7], and others studied the ultimate bearing capacity of steel pipe nodes containing 1/4 ring plate and ringless plate on the basis of test and finite element analysis, and the ultimate bearing capacity of 1/4 ring plate specimen is higher than that of ringless plate specimen and proposed the suggested formula for the ultimate bearing capacity of the nodes of the ringless plate and 1/4 ring plate, which is a guideline for the actual engineering. Hu Jianfeng [8] and others studied the compressive bearing capacity characteristics and damage mechanism of T-shaped insert nodes of Q460 high-strength steel pipe without annular stiffening ribs utilizing finite element analysis, plastic hinge line calculation theory and relevant codes and proposed a formula for calculating the compressive bearing capacity of nodes, where the wall thickness of the steel pipe, the outer diameter, and the length of the nodal plate have a greater impact on the nodal bearing capacity. Yan Lixin [9] from Xi'an Jiaotong University and others conducted experimental and numerical studies on the ultimate bearing capacity of the complete ring plate node of the steel pipe tower and, through theoretical analysis, put forward a proposed formula for the design of the ultimate bearing capacity of the full ring plate node of the steel pipe tower, and the ring plate weld should not be placed perpendicularly to the connecting plate. Li Xiaolu [10] carried out footstep test on KT-type 90-degree ring plate node and X-type full ring plate node, obtained the ultimate load capacity of the node, and put forward the proposed formula for the maximum load capacity of the two types of nodes, KT-type node damage form manifested in the ring plate control and the main material control of the two types of morphology, the damage form of X-type node damage occurs as the main material is recessed, and at the same time the ring plate is warped, the setup of the ring plate can improve the ultimate load capacity of the node, and the increase in the height and thickness of the ring plate can improve the node capacity, and the X-type node force form shown in Fig. 1(a). Guo Yong [11] and others conducted experimental research and theoretical analysis on the load-carrying performance of single-ring stiffened nodes when loaded symmetrically and gave the mechanical model and formula for the calculation of the load-carrying capacity of this type of nodes, and it is desirable to improve the stiffness ratio of the ring plate to the node plate for the design of ring plate stiffened nodes.

Liu Hongjun [12-13] et al. experimental study of ring plate stiffened rib transmission tower nodes and node failure is divided into two damage modes: main pipe wall bulge and invagination, proposed an analytical model for estimating the ultimate bearing capacity of steel pipe ring-type stiffened rib nodes, which can accurately reflect the development of plastic hinges when the node is locally flexed, according to the theory of energy, and the principle of virtual work proposed the formula of the inserted plate node bending ultimate bearing capacity, the main pipe wall thickness, pipe diameter, the length of the node plate, the ring-type stiffened rib plate height and thickness affects node capacity, the ring-type stiffened ribs to enhance the node bending bearing capacity, and to reduce the phenomena of stress concentration in the joints between the steel tube and the node plate and the ring plate. Bai Qiang [14-15] et al. studied the ultimate bearing capacity of 1/4 and 1/2 annular ribbed steel pipe insert connection nodes based on steel pipe control through tests, and the maximum bearing capacity of the nodes was obtained by numerical analysis, and the action of bending stresses on the nodes under the control of the steel pipe can accurately reflect the stress distribution of the nodes when they are locally buckled. Yang Ziye [16-17] et al. conducted a foot-scale experimental study on the bending performance of 90° 180° nodes of steel pipe tower ring-type ribbed nodes and proposed a formula for bending load capacity by using plasticity theory and regression analysis, and established the interaction relationship between the ultimate strength and the everyday stress of the main material, and the damage modes of ring-plate ribbed steel pipe nodes are divided into the main pipe local buckling and ring-plate-main pipe model transverse plastic deformation, and the node damage modes are correlated with the main pipe stress, and the node stress form is shown in Fig. 1(b).



(a) Pressured (b) Bend (c) Hysteresis

Fig.1 Nodal force form

Li Guoqiang [18] et al. and Liu Chuncheng [19-20] et al. used finite elements to study the seismic performance of TY-type nodes, K-type nodes, and space double K-type nodes of steel tube towers and obtained their hysteresis curves, skeleton curves, and energy consumption coefficients, and analyzed the effects of the parameters of main pipe diameter and branch pipe diameter, node plate thickness, main pipe axial pressure, connecting insert thickness, and branch pipe gap dimensions on the hysteresis performance of TY-type nodes, K-type nodes, and space double K-type nodes. The influence of these parameters on the seismic performance is summarized as follows: TY-type node itself has good seismic performance, and when loaded repeatedly, the increase of diameter and thickness ratio of the main pipe increases the node bearing capacity, hysteresis performance, and stiffness, and the increase of diameter and thickness ratio of branch pipe and thickness of connecting plug plate increases the node energy dissipation capacity, and the increase of axial pressure ratio of the main pipe and branch pipe decreases the hysteresis performance of the node and total energy dissipation capacity, and the increase of gap size decreases the hysteresis performance and total energy dissipation capacity, and the increase of gap size increases the hysteresis performance and total energy dissipation capacity of the node. Decrease, the gap size increases, and the node bearing capacity hysteresis performance decreases; the K-type node itself has good seismic performance, the main axial pressure increases, node seismic performance decreases, and due to stress concentration occurs damage, the main branch diameter and node plate thickness changes can improve the seismic performance of the round tube node, the branch gap size of the node hysteresis performance is not obvious; space KK-type node has a good capacity and plastic deformation capacity, diameter thickness ratio increases, node hysteresis performance, total energy dissipation capacity. Plastic deformation capacity: The smaller the diameter-thickness ratio and the main branch pipe angle, the better the hysteresis performance of the node. The larger the ratio of the outer diameter of the main material, the larger the ratio of the node plate to the thickness of the main material, and the better the hysteresis performance, the node force form shown in Figure 1(c).

3. Conclusion

The development process of transmission towers, compression, bending, and cyclic reciprocating conditions are synthesized, and there are fewer studies on the multi-ring plate nodes of transmission steel pipe towers so that the safety and economy of transmission towers can be guaranteed.

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