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Large-Section Cable Laying Method of High-Drop and Narrow Environments

Guanghua He[*], and Peilun Zhang[a]

Jiangsu Wuxi power supply company of SGCC, Wuxi, China

*Corresponding author e-mail: 13585086631@163.com, [a]15365238267@163.com

Abstract. The increase of urban power supply and the development of three dimensional traffic motivated more large-section cable projects of high-drop and narrow environment, but the corresponding study of cable laying methods was still blank. Based on the situation above, this paper proposed a new cable laying method and developed the matching tools to make the width of cable tunnel, the position of cable put into the wellhead and the height of cable line become adjustable. The actual construction situation showed that the method proposed in this paper had the good engineering practicability and greatly improved the laying efficiency and quality of large section cable.

1. Introduction

Cable laying is an important part of cable construction. Once the laying method is improper, it will cause the cable surface scratched or seriously damaged [1]. Therefore, it is essential to adopt an effective cable laying method. At present, with the increase of urban power supply, the transmission capacity of cables is also increasing [2, 3], resulting in more and more demands for large section cables. In order to save the civil construction investment, many special passages with fewer loops adopt the design mode of the circular small-diameter jacking tunnel and the compact caisson, resulting in narrow passage room. In the process of urban cable laying, the terrain of high-point crossings is increasing with the development of highways, high-speed rails, and light rails on the ground [4]. The situation above brings new challenges to the safe operation of the cable.

For the problem of laying large section cable lines in high-drop and narrow environment, this paper developed multi-function guide sliding bracket, universal cross-arm mounting fixture, plug-in fixture and cable conveyor based on hydraulic equipment, formed the corresponding cable laying method that can adjust the cable to the appropriate position. Combined with on-site application, analyzed the structure, portability, the requirements of space layout, dynamic stress of the new laying tools, so as to meet the requirements of site applicability, economy and the safe operation, and finally ensuring the quality control requirements of cable laying and installation.

2. Problems of traditional cable laying methods

The traditional cable laying methods was mainly for cables with a section of 1000 mm^2 or less [5], and existed many problems when used in a complex tunnel [6].

1) When the cable was stored and transported, it was usually wrapped around the cable reel. Once installed and used, the cable would be straightened and dragged. At this time, with the cable reel

rotating, the discharged cable would swing in left and right directions. At present, the method of constructing a roller bracket was usually adopted, that is, passing a steel pipe through a perforated plastic roller to form a bracket, thereby avoiding the friction between the cable and the ground, and successfully introducing the cable into the working well. However, the friction between the plastic roller and the steel pipe was still sliding friction, so the frictional resistance was large and the movement along the steel pipe was inconvenient.

2) The tunnel was usually erected by a steel tube of triangle type, and the pulley was installed on the horizontal side [7]. Due to the narrow passage of the circular small-diameter jacking tunnel and the compact caisson, although the triangular erecting method could play a role of stable support, it made the room for walking occupied. This lead the low work efficiency and difficulty in emergency rescue.

3) In the process of laying power cable, cable conveyor was needed [8]. But for large-section cables, and the required conveyor was bulky and inconvenient to transport. If adopted the past method that using steel pipes to fix the cable conveyor, once the position of the conveyor was fixed, it was difficult to adjust, which may cause the damage of the cable during the laying process. If used the cascading platform, the height cannot be fine-tuned, and it would take large room and need the cumbersome installation process.

3. Large-section cable laying method and matching tools

In view of the problems of traditional cable laying method, this paper designed the corresponding cable laying method that could adjust the cable to the proper position, and developed the matching tools to realize the function above.

3.1. Matching tools

3.1.1. Multi-function guide sliding bracket. The bracket comprises a multi-functional guide pulley and a sliding rod, as is shown in Figure 1. The sliding rod and the multifunctional guiding pulley are two independent components, and the lower frame body of the multifunctional guiding pulley is mounted on the rod of the sliding rod, which is matched with the gap of the multifunctional guiding pulley. In order to facilitate the movement, the device is equipped with three small pulleys on each side of the bottom of the pulley and two limit pulleys on both sides of the main pulley.

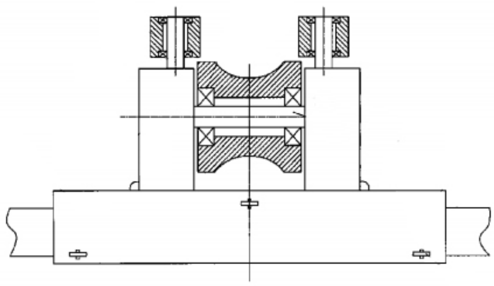

Figure 1. Multi-function guide sliding bracket.

3.1.2. Universal cross-arm mounting fixture. The device consists of a fixed base clamp with the adjustment hole, the fixed panel, the connecting support tube, the 180° rotatable cannula, and the semi-hug hoop, as is shown in Figure 2.

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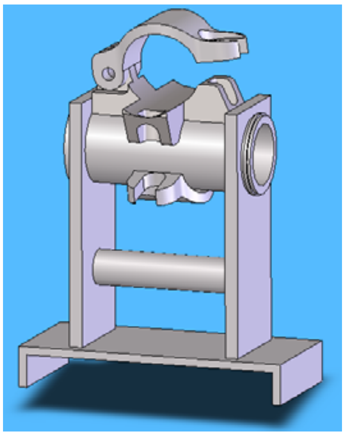

Figure 2. Universal cross-arm mounting fixture.

1) The width of the base covers the width of the cross arm bracket of all current manufacturers. Through the flat long mounting hole of the base, the spacer screw can be used for fixing, so as to meet the requirements of mounting firmly on the cross arm bracket of different structures and sizes.

2) The design of the connecting support tube and the fixed panel makes the fixing device relatively firm.

3) The steel pipe can be inserted into semi-hug hoop at the top to become one fixed end of the laying frame of door type, and the hoop can be adjusted by 180° rotation, thereby achieving angle adjustment in different directions.

In order to ensure the strength and rigidity of the device, according to the situation of laying rack per 30m, considered the laying equipment, the laying frame and the cable weight, set a safety factor of 1.3 times, determined the load of 100kg. Verified the stress and strain of the cable bracket by the known load. The load of the key components of the cable bracket is as follows.

Figure 3 is a stress cloud diagram of the critical components of the cable bracket under the rated load. It can be seen from the figure that the maximum stress of the cable bracket is 3.3MPa, and the corresponding material is Q235, the yield strength is 235MPa, which is much larger than the maximum stress. Thereby, the strength of the cable bracket meets the requirements.

Figure 4 is a strain cloud diagram of the critical components of the cable bracket under the rated load. As can be seen from the figure, the strain of the cable support is concentrated at the two end points, and the maximum value of strain is 0.00037mm, which can be ignored. As a result, the stiffness of the cable bracket meets the design requirements.

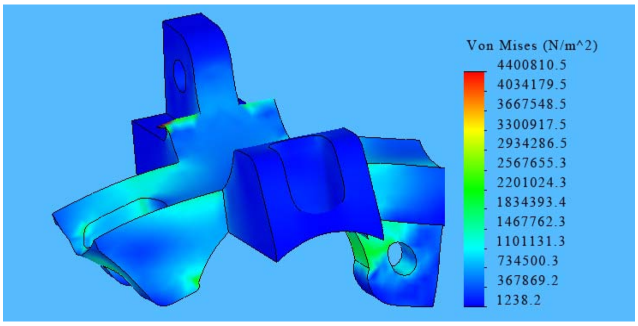

Figure 3. Stress cloud diagram of the bearing component of cable bracket (magnification 1000 times).

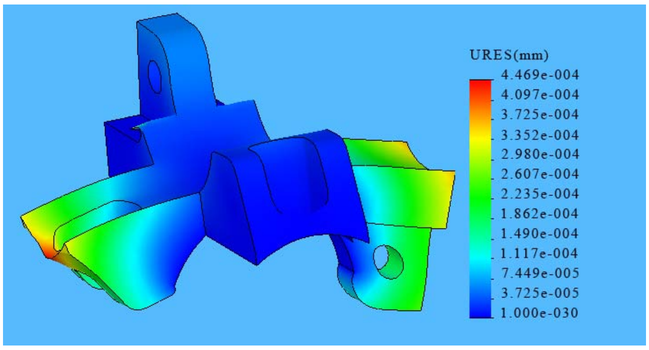

Figure 4. Strain cloud diagram of the bearing component of cable bracket (magnification 1000 times).

The stress and strain of the main bracket body of the cable bracket are shown in Fig 5 and Fig 6. It can be seen from Fig 5 that the maximum stress of the main bracket is concentrated in the lower part, and the maximum value is 12MPa, which is much smaller than the required strength of the material of 235MPa. Therefore, the strength meets the design requirements. It can be seen from Fig 6 that the maximum strain of the main bracket is concentrated in the lower part, the maximum value is 0.016mm, which can be ignored, and thus the stiffness satisfies the design requirements.

According to the verification, the design can meet the stiffness and strength requirements for practical use.

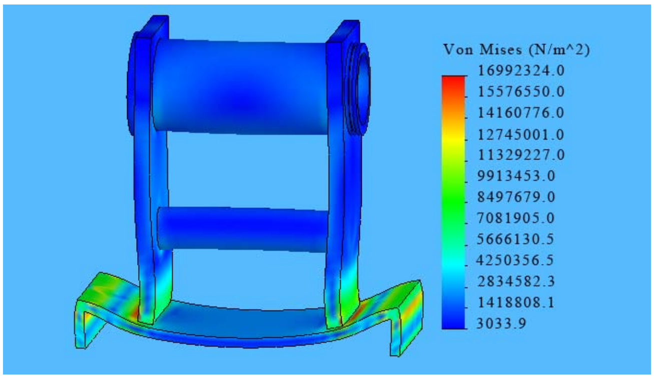

Figure 5. The stress cloud map of main bracket (deformation magnified 1000 times).

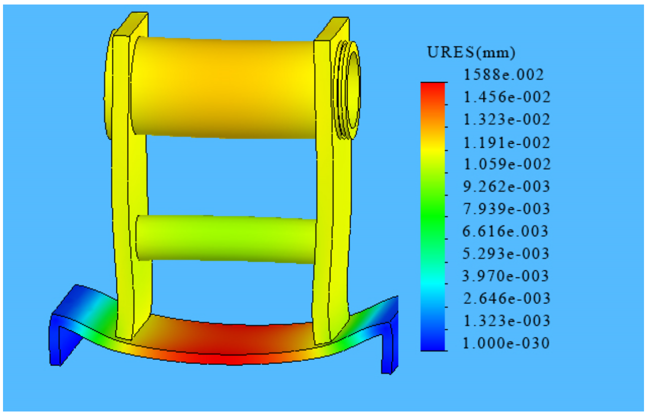

Figure 6. The cloud map of the main bracket (magnification 1000 times).

3.1.3. Plug-in fixture. As is shown in Fig 7, the one side of the blade body 1 is an insertion portion 2, and the other side is a mounting portion 3, and the insertion portion 2 is used to insert the inner side of the bracket. The mounting portion 3 is provided with the back-spinning fixing hole 4 for fixing the cross-bar of the scaffolding. Gaps 6 lies between the insertion portion 2 and the mounting portion 3, and it is generally uniform with the thickness of the side of cable bracket to ensure that the blade body 1 cannot be loosened after being inserted into the bracket.

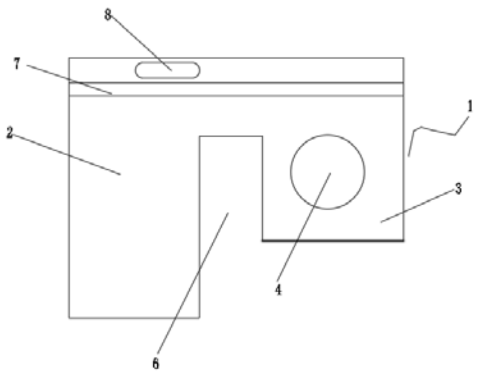

Figure 7. Plug-in fixture.

3.1.4. Cable conveyor based on hydraulic equipment. Developed a manual hydraulic lifting platform to freely lift the platform to the required height, facilitating the fixing of the conveyor. As is shown in Figure 8.

1) Used the mechanical principle of multi-layer scissor lift and combined with the actual environmental height of the channel to adjust the possible range, so as to obtain the lifting height of the platform.

2) In combination with the load-bearing range of large-section cable construction, according to the self-weight of the large-section cable and cable conveyor, calculated the load on the load-bearing cable of the single platform to obtain the load of the design platform.

3) Selected the size of platform table according to the size of the special cable conveyor of the large-section cable.

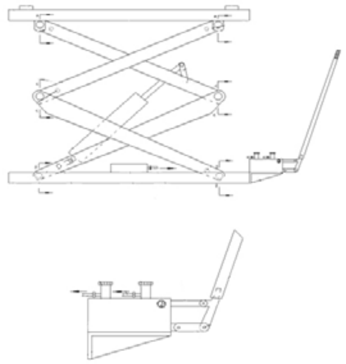

Figure 8. Cable conveyor based on hydraulic equipment.

3.2. Large-section cable laying method

3.2.1. Position adjustment of cable put into the wellhead. Through the development of the multi-functional guide carriage, this paper realized the rapid adjustment of the position of the cable put into the wellhead during the cable laying process, and reducing the torque and frictional resistance generated by the swinging of cable from the cable tray to the inlet section. The limit pulley not only ensured that the friction resistance of the cable was not increased during the cable laying process, but also made the cable does not come out of the pulley.

3.2.2. Radial position adjustment. Through the development of the universal cross-arm mounting fixture and the corresponding plug-in fixture, the traditional bracket with the channel diameter as the fulcrum is transformed into the I-shaped bracket erected in the channel radius, that is, the plug-in fixture is used as a fixed point, solving the problem of lacking another fulcrum in the radius, thus leaving a channel for personnel, material equipment transportation, improving work efficiency and ensuring the safety of personnel escape. The corresponding laying method is shown in Figure 9.

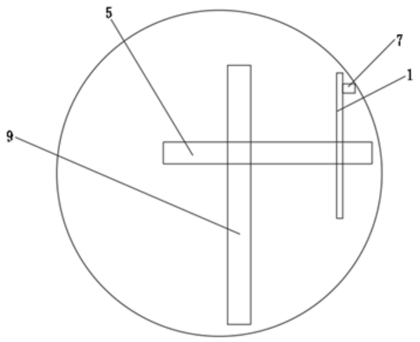

Figure 9. Schematic diagram of the radial position adjustment.

Referring to Figure 7 and Figure 9, the cable bracket and the scaffold are placed in the cable laying passage, and the insertion portion 2 of the plug-in fixture is inserted into the inside of the cable bracket. Then, a crosspiece radius backing support 5 is inserted into the back-spinning fixing hole 4 to fix the cross-bar of the scaffold, and a vertical back-retracting support 9 is set on the cross-sectional radius back-spinning support to form a radius I-frame. Finally, arranged a low-friction pulley on the crosspiece radius backing support 5, adjusted the position of the vertical back screwing 9 on the crosspiece radius backing support 5 to make the half room of the passage according to the site environment.

3.2.3. Height adjustment of cable lines. By developing the hydraulic lifting platform of the cable conveyor, achieved the free lifting of the platform, so as to avoid the low efficiency caused by a large number of secondary handling and the cable bruised caused by human factors in the process of repetition. The corresponding laying method is shown in Figure 10.

Placed the scaffold 1 in the cable passage, and placed the low-friction pulley on the scaffold, and the position of the low-friction pulley is slightly higher than the cable bracket. Arranged the cable conveyor based on hydraulic lifting platform 3 in the passage, one side of the cable was placed on the conveyor 4, and adjusted the height of the hydraulic platform 3 of the cable conveyor to make it slightly higher than the position of the cable bracket 5. Finally, laid the cable on the low-friction pulley, and pushed the cable into the cable bracket 5 after the cable is laid.

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4. Verification of site construction

Combined with engineering practice, this paper proposed the large-section cable laying method and developed the matching tools to effectively ensure the construction quality of large-section cable laying engineering in high-drop and narrow environment and improve the construction efficiency. The situation of site operation is shown in Figure 11 and Figure 12.

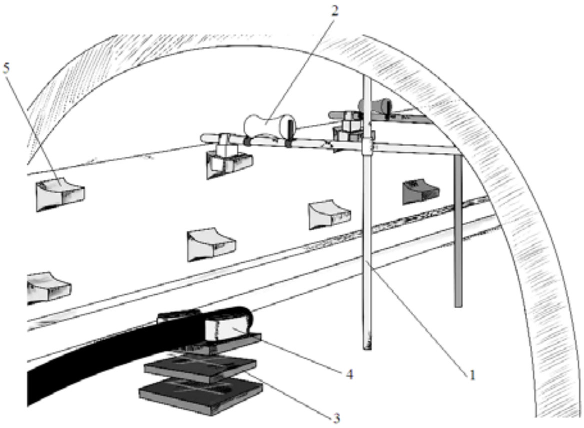

Figure 10. The device structure of the height adjustment

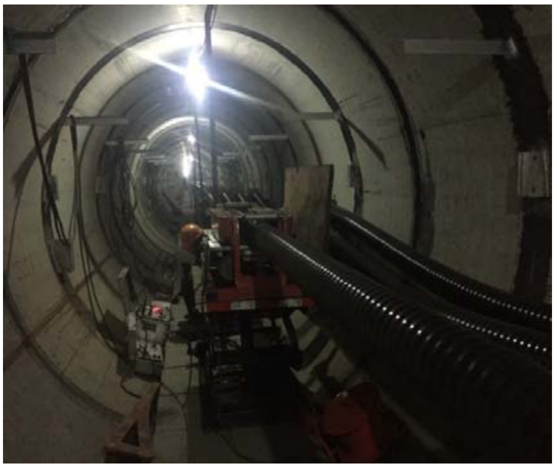

Figure 11. Site map of the radial position adjustment method

Figure 12. Field work diagram of multi-function guide sliding bracket.

5. Conclusion

This paper proposed the large-section cable laying method adaptable to the high-drop and narrow environments for the first time, which realized the integrated operation of adjustment of radial position and cable height in high-drop and narrow passage, and avoiding potential quality hazards, improving the efficiency of personnel operations and first aid escape.

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