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Review of Power Supply and Distribution Construction Technology for Highway Electromechanical Engineering

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Abstract: In recent years, China has made significant progress in the construction of highways, resulting in an improved highway network that has provided robust support for economic and social development. However, the rapid expansion of highway construction, power supply, and distribution has led to several challenges in mechanical and electrical engineering technology. Ensuring the safe, stable, and cost-effective operation of the power supply and distribution system to meet the diverse requirements of highway operations has become a pressing issue. This article takes an example of a highway electromechanical engineering power supply and distribution construction project to provide insight into the construction process of highway electromechanical engineering power supply and distribution technology.

Keywords: Highway; Mechanical and electrical engineering; Power supply and distribution construction technology; Construction process

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1. Introduction

With the deepening of national infrastructure construction and the rapid development of the modern transportation industry, highways have become an important channel for rapid communication between cities. To ensure the stable operation and driving safety of highways, highway mechanical and electrical engineering plays a vital role. Among them, the power supply and distribution system are the cores of highway electromechanical engineering, and the quality of its construction is directly related to the safety, stability, and efficiency of the entire highway system [1,2]. Therefore, it is crucial to study the construction technology of the power supply and distribution system of expressway electromechanical engineering.

2. Project overview

The highway's contract section is 15.16 km long. This section is an important transportation hub connecting

the north and the south and plays a key role in developing the regional economy. Due to the large traffic flow, complex road sections, and high operating load of electromechanical equipment, the stability and reliability of the power supply and distribution system are particularly important.

3. Construction process of power supply and distribution for highway systems

3.1. Project preparation

3.1.1. Personnel organization

A professional and efficient project team should be formed before constructing the power supply and distribution system. The team members should include project managers, electrical engineers, technicians, safety officers, quality inspectors, and construction personnel. The project's participants should possess professional skills and qualifications, and their responsibilities should be clearly defined.

3.1.2. Equipment and material procurement

The allocation of staff members is followed by the purchase of equipment and materials. The equipment/materials involved include transformers, high and low-voltage switch cabinets, cables, lighting equipment, wires, pipes, and others. It is necessary to ensure that the quality and performance of equipment and materials meet engineering requirements, and the convenience of transportation and installation must be considered [3].

3.1.3. Design review

Before construction, the design drawings of the power supply and distribution of the mechanical and electrical engineering should be comprehensively reviewed to ensure that the design complies with the requirements and meets the actual needs of the project. Problems in the design should be addressed promptly through effective communication with the design unit, so as to ensure the smooth progress of the construction [4].

3.1.4. Construction site preparation

The construction site should be cleaned before construction. Besides, it is important to check whether all construction equipment and tools are complete and in good condition.

3.1.5. Development of security measures

Detailed safety measures should be formulated before construction, including equipment safety, personnel safety, fire safety, etc. Safety training must be conducted for all construction personnel so that they understand and comply with the safety regulations [5].

3.1.6. Preparation of construction plan

According to the actual situation of the project and the construction period requirements, prepare a detailed construction plan, including construction progress, personnel and equipment configuration, etc. Plans should be flexible enough to accommodate unexpected situations that may arise.

3.1.7. Technical briefing

Before construction, technical briefings should be conducted on all construction personnel and technical personnel to ensure that they understand the technical requirements, construction difficulties, and key points of the project. At the same time, new processes and technologies should be introduced to improve construction efficiency and project quality.

3.2. Construction measurement and calibration

In the power supply and distribution construction of highway electromechanical projects, construction measurement, and calibration are the key links, playing a vital role in the quality and safety of the entire project. Through accurate measurement and calibration, it can be ensured that the location, height, angle, and other parameters of equipment installation meet the design requirements, thus ensuring the normal operation of the power supply and distribution system. Besides, accurate measurement and calibration can prevent safety risks caused by improper installation.

The main aspects of construction measurement and calibration are summarized in **Table 1**.

Table 1. Contents of measurement and calibration of power supply and distribution construction for highway electromechanical projects

Measurement and calibration content	Details
Equipment positioning	The location of installation of the power supply and distribution equipment should be determined based on the design drawings and actual site conditions. Their positions should be measured with proper tools to ensure accurate positioning.
Equipment installation height	The installation height of the equipment should be determined based on the type of equipment, installation requirements, safety regulations, and operation and maintenance requirements.
Equipment angle adjustment	For equipment that needs to be installed at a certain angle, such as light poles, wire poles, etc., angle measurement and adjustment must be carried out. The equipment's angle should be determined based on relevant regulations and usage requirements.
Line positioning	Positioning measurements of power supply and distribution lines, including line directions, and intersections, should be conducted. The circuit layout should be reasonable and meet design requirements and safety regulations.
Line calibration	The line should be calibrated according to the design drawings and actual site conditions. Information like line name, length, and direction, should be clearly documented to ease identification.

The tools used for related measurements and calibration should be highly accurate. The safety regulations should be strictly observed to ensure the safety of personnel and equipment. the design drawings must be carefully checked to ensure that the measurement and calibration data are consistent with the design requirements. Adjustments and corrections must be made promptly if deviations or errors are found.

3.3. Excavation and infrastructure construction

3.3.1. Excavation

Excavation is the prerequisite for infrastructure construction and must be carried out per design requirements and construction plans. During the excavation process, the following points should be noted: First, obstacles at the construction site, such as trees, stones, buildings, etc., should be removed before excavation. Second, a suitable excavation method should be selected based on the results of the geological survey. Reinforcement is necessary for soft soil foundations. Third, the depth and width of excavation must be controlled to avoid over-excavation or under-excavation. The stability of the slope should also be considered to prevent landslides. Fourth, the excavated earth must be properly stacked and should not affect the progress and safety of construction.

3.3.2. Infrastructure construction

Infrastructure is an important part of the power supply and distribution system and is directly related to the stability and safety of the equipment. First, the corresponding concrete foundation must be designed and made according to the equipment specifications and weight. The foundation must be firm and stable, able to withstand

the weight and vibration of the equipment during operation. Secondly, embedded parts must be installed according to the design drawings, and the parts must be accurately positioned and firmly fixed [6]. The embedded parts should not be affected when pouring concrete. Furthermore, to ensure the equipment's safe operation, a grounding device needs to be installed. The grounding device must meet the design requirements with sufficient grounding resistance [7]. In addition, cable trenches should be set up to protect cable lines and prevent external damage and corrosion. The size and depth of the cable trench must meet the design requirements, and the bottom of the trench must be treated as necessary.

3.4. Laying cables and installing road lighting

3.4.1. Cable laying

Cable laying is an important link in the power supply and distribution system of highway electromechanical engineering. The cable models and specifications should be determined based on design requirements and conditions. The cable's cross-section, voltage level, insulation level, mechanical strength, and environmental adaptability should suit the project. The cable path should be planned properly to ensure that the length of the cables is suitable. The bending radius of the cable should be minimized to avoid cable damage. The laying method should also be selected properly. For example, direct burial of cables requires digging a cable trench, placing the cable in the cable trench, and filling it with sand. The cables on the bridge need to be fixed according to the design requirements. Cable splicing is required when the cable is too short or when cables of different lengths need to be connected. The joints should have fireproof and waterproof properties must be ensured, and their mechanical strength and electrical properties must be consistent with those of the original cables. After the cable laying is completed, the cables must be marked to facilitate future maintenance and management.

3.4.2. Road lighting installation

Lighting is an important part of highway electromechanical projects' power supply and distribution system, providing good visibility for road users and improving driving safety. Parameters like luminous intensity, beam angle, color temperature, weather resistance, waterproofness, and wind resistance should be considered when selecting lamps for road lighting [8]. Lamps with low energy consumption are preferred to achieve energy conservation, emission reduction, and low-carbon goals [9]. Lamp poles are an important part of road lighting. Their positions and height should be determined through careful consideration. They should also be firmly fixed and undergo anti-corrosion treatments to extend their service life. Lighting lines include power lines, control lines, etc., and their cross-sections, insulation layers, etc., must meet relevant requirements. The control lines should have a good shielding layer and anti-interference ability. Line crossing and knotting should be avoided. The horizontality and verticality of the lamps should be ensured to prevent uneven light spots. The height of the lamps should also be suitable to provide the best lighting effect.

3.5. Installing and debugging power distribution equipment

Other power distribution equipment must be installed after the road lighting equipment is installed. The location of the power distribution equipment must be determined according to the design drawings, and the corresponding foundation for each equipment should be made. The foundation should be able to withstand the equipment's weight and be effectively transferred to the ground. It is important to avoid damaging the equipment during transportation. Then, the power distribution equipment is installed on the foundation. During installation, the positioning and fixation of the equipment should be taken care of to ensure its stability and safety. Finally, the power distribution equipment is connected to power supplies, loads, and other equipment. During the connection process, it is essential to ensure that the cable model and specifications are compatible

with the equipment and that the cable is installed properly [10].

3.6. Debugging process

After installing the equipment, it is necessary to conduct inspection and debugging [11]. The first step involves performing a power-on inspection of the power distribution equipment to ensure its power supply is functioning normally. Then, various functions of the power distribution equipment need to be tested, such as the equipment's switch control and safety functions. Moreover, the performance of the power distribution equipment must be tested, including the power factor, efficiency, and other parameters. Ensure that the equipment can meet the design requirements and provide a stable power supply during operation. Finally, possible faults in power distribution equipment should also be investigated and dealt with. By simulating fault conditions, the fault-handling capabilities of the equipment are checked to ensure that the equipment can be handled promptly and effectively when a fault occurs.

3.7. Construction finishing

3.7.1. Construction documentation

All construction processes, equipment installation details, problems encountered and solutions, etc., should be recorded in detail. These documents must be compiled into formal construction records and technical reports during the closing phase. Construction records should include construction time, personnel, equipment, and procedures. The technical report should include an overview of the project, construction methods, problems encountered and solutions, test results, etc.

3.7.2. Training and handover

At the end of the project, corresponding training and handover work are required to ensure that the operation and maintenance personnel can operate and manage the equipment proficiently. The operation and maintenance personnel must receive training in equipment operation, daily maintenance, and emergency response procedures. Moreover, they need to conduct a thorough handover with the owner or operator, which involves providing equipment operation manuals, maintenance guides, technical reports, etc. It is also crucial to ensure that they are proficient in operating the equipment and capable of addressing simple problems.

3.7.3. Preparation for acceptance

In the final stage of the project, acceptance preparations are also required to ensure smooth acceptance. It is important to verify that all equipment meets the design requirements and to have a clear understanding of the specific standards and procedures for acceptance. Additionally, it is necessary to ensure that the acceptance site meets the requirements and that all equipment has been properly installed and debugged [12].

3.7.4. Defect handling

During the project closing phase, some defects or problems may be discovered. These problems need to be dealt with and resolved promptly. The problems or defects should be carefully inspected and recorded during system inspection and acceptance. Then, a corresponding solution should be developed for each problem and implemented as soon as possible. Emergency plans should be developed if the problem cannot be solved quickly.

4. Conclusion

With the advancement of science, technology, and societal progress, power supply and distribution construction

technology must prioritize efficiency while also considering environmental protection and energy conservation. As a critical national infrastructure, expressway power supply and distribution construction technology must continually innovate to align with the trends of intelligence and automation. Looking ahead, intelligent construction will emerge as a pivotal development direction for highway electromechanical projects. Technologies such as Building Information Modeling (BIM), Internet of Things (IoT) applications, and intelligent robots will be extensively employed at construction sites to enhance efficiency, reduce costs, and ensure safety.

In the future, as more efficient, intelligent, and green power supply and distribution construction technologies are developed, sustainable development in the highway and improvement of user travel experiences can be achieved.

Disclosure statement

The author declares no conflict of interest.

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