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Mountain Micro Pile Drilling Rig and Micro Pile Foundation Construction Technology

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Abstract. As the construction of transmission lines increasingly extends to deep mountains and ridges, the research on mountainous micro-pile drilling rigs and transmission line micro-pile foundation construction technology has become increasingly important. This article discusses the characteristics of mountain micro-pile drilling rigs in the construction of micro-pile foundations for transmission lines and its application in mountain construction. The article introduces the structure and working principle of the mountain micro-pile drilling rig, and analyzes its adaptability in different environments. In addition, the article also elaborates on the construction technology of micro-pile foundation for transmission lines, focusing on the construction process of micro-pile foundation based on the down-the-hole mountain micro-pile drilling rig. This research provides valuable ideas and methods for the construction of mountain transmission lines, and has certain theoretical and practical value for improving construction efficiency, ensuring project quality, and saving costs.

Keywords. Transmission lines, mountain micro-pile drilling rig, micro-pile foundation, construction technology

1. Introduction

Micro-pile foundation, also called small-diameter pile, is a deep foundation with a diameter usually less than 0.40 meters but a large slenderness ratio (generally greater than 30). The micro-pile foundation uses small drilling and grouting equipment to form holes in the foundation, and then the steel cages and grouting pipes required by the design are inserted into the holes, and pressure grouting is used to form piles or fine stone concrete is poured into piles [1]. In transmission line projects, micro-pile foundations are increasingly used. Micro-pile foundation can effectively solve foundation treatment problems in various complex geological environments, such as weak foundations, uneven foundations, composite foundations, geological fault zones, etc. It is an effective method for new foundation treatment in power engineering.

In the environment of complex mountain terrain, the construction of micro-pile foundation faces many challenges. Especially when it comes to the selection of drilling

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equipment, conventional pile drivers are often not suitable for use in mountainous environments due to their heavy weight and difficulty in transportation [2]. To meet this challenge, mountain micro pile drilling rigs came into being. This new type of drilling rig has a compact structure, light weight, modularization, easy transportation, and high work efficiency. It is especially suitable for construction in complex terrains such as mountains, slopes, hills, etc.

There is still a lack of systematic research on its application effect in actual projects. This paper will focus on the application of mountain micro-pile drilling rigs in the construction of micro-pile foundations for transmission lines. A innovative construction technology of micro-pile foundation for the mountain environment is proposed. The performance characteristics of the mountain micro-pile drilling rig are analyzed, and its application effect in actual projects is explored, in order to provide reference for future foundation construction of mountain transmission lines.

2. Mountain Micro Pile Drilling Rig

2.1. Structure and Composition

In the current market, mountain micro pile drilling rigs show a diversified trend, and their types are relatively rich. These models can be divided according to their walking methods: crawler type (figure 1) [3], bionic self-balancing type (figure 2), towed type and fixed type (figure 3), etc.; according to the differences in the structure of the whole machine, they It can be further divided into two types: integrated and modular; from the perspective of drilling operation methods, it includes three types: auger drilling, rotary drilling and down-the-hole drilling. These different types of mountain micro pile drilling rigs can cope with various engineering needs and provide diversified solutions for the foundation construction of transmission line projects.

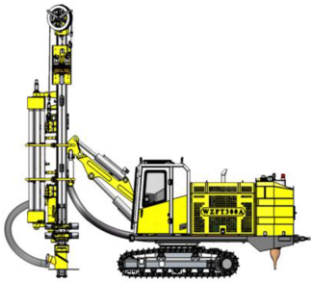

Figure 1. Schematic diagram of crawler mountain micro pile drilling rig.

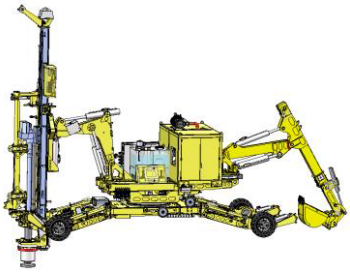

Figure 2. Schematic diagram of bionic mountain micro pile drilling rig.

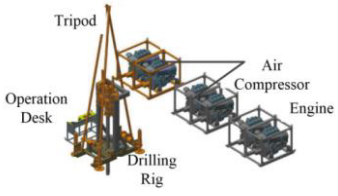

Figure 3. Schematic diagram of fixed mountain micro pile drilling rig.

While there are many types of mountain micropile drill rigs, they generally all have the same basic components:

(1) Chassis: Provides a stable and mobile foundation for the entire mechanical equipment under complex terrain conditions.

(2) Frame: As the skeleton of the machine, it plays an important role in carrying and connecting various components.

(3) Hydraulic power unit: Responsible for converting mechanical energy into hydraulic energy to drive the drilling rig for drilling operations. The hydraulic power device mainly consists of a hydraulic pump, a hydraulic motor, a hydraulic cylinder, a control valve, a fuel tank, etc.

(4) Working device: including drill bit, drill rod, rotating device and feeding device, etc. These components work together to achieve effective drilling of pile foundations.

(5) Dust removal device: Reduce dust pollution during the drilling process and protect the safety and health of equipment and workers.

(6) Control device: The control system of the equipment allows the operator to accurately control the entire drilling process. The operation methods include cab operation, open console operation and wireless remote control operation.

(7) Aerodynamic device (only equipped for down-the-hole operation): Provides high-pressure air required during the drilling process to achieve efficient and fast drilling operations.

2.2. Working Principle

There are three main drilling methods of micro pile drilling rigs, and their working principles are as follows:

(1) Down-hole drilling

The pneumatic impact hammer of down-hole drilling is designed as shown in figure 4, which is composed of axle, compressed mechanism and hammerhead. Compressed air is used to drive the impact hammer for repeated impacts to break the rock and achieve the purpose of drilling [4]. Its advantages are: In hard rock geological environments, pneumatic impact hammer (figure 4) drilling efficiency is usually higher than traditional rotary drilling methods. For complex rock structures or fault zones, pneumatic hammer drilling can provide greater penetration capabilities. Pneumatic impact hammer drilling can accommodate a variety of different drilling angles and depths. The disadvantage is: due to its working principle, greater noise and vibration will be generated during the hole forming process, which will have a greater impact on the environment. Additionally, it has higher running costs.

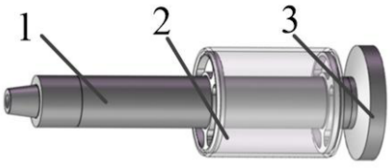

Figure 4. Down-the-hole drilling tools: pneumatic impact hammer:1-Axle; 2-Compressed air; 3-Hammerhead.

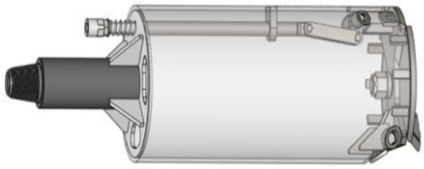

Figure 5. Rotary drilling tools: rotary drilling bucket.

(2) Rotary drilling

The rotation of the drill and the weight of the drill bit (figure 5) are used to cut and break the formation, and then the broken rock and soil are brought out of the hole through the lifting of the drill pipe [5].

Its advantages include: This drilling method can quickly drill large diameter and deep holes, and the diameter and depth of the hole can be accurately controlled. Disadvantages: Not suitable for drilling in hard rock or formations with large stones, as these conditions may cause serious wear on the drill bit or make it impossible to enter the formation. Additionally, if there is too much moisture in the formation, it may cause the hole walls to collapse.

(3) Spiral drilling

Use an auger bit (figure 6) to rotate and lift to stir up and lift the soil or rock in the hole to the surface. This method is effective when dealing with softer soil or gravel-type geological conditions. The main working principle is: the auger bit rotates driven by the drill and comes into contact with the soil or rock on the ground, stirring and lifting it to the ground through cutting and crushing.

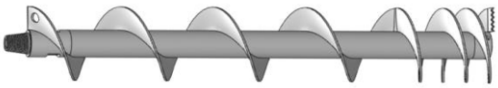

Figure 6. Auger drilling tools: Auger drill pipe.

Its advantages are: drilling speed is faster than traditional drilling methods, and foundation construction can be completed quickly. Drilling produces less noise and vibration and has less impact on the environment. The disadvantage is: it is difficult to form holes when dealing with harder geological conditions or large rocks. In addition, auger drilling may have an impact on the surrounding soil structure, potentially altering the physical properties of the soil [6].

In summary, the down-the-hole drilling method is suitable for rocks with higher hardness or mixed formations. Rotary drilling is suitable for medium-hard or soft ground, such as clay, sandy soil and some softer rocks. Auger drilling is mainly suitable for loose, sticky or high water content strata, such as sand, silt, etc.

3. Construction Technology of Micro-pile Foundation in Mountainous Areas

3.1. Construction Process

Under the geological conditions of most mountainous areas, the presence of hard rock makes rotary excavation and auger drilling methods less adaptable, and the resulting excavation difficulties and low efficiency are unavoidable [7][8]. Therefore, this article mainly introduces the construction technology of micro pile drilling rig based on down-the-hole type. The process of micro pile foundation construction technology usually includes the following steps (figure 7):

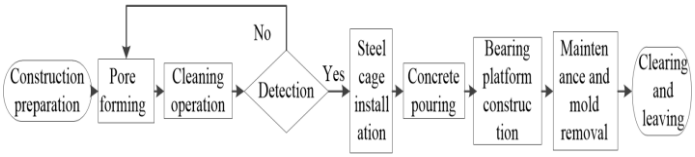

Figure 7. Flow diagram of Micro pile construction process.

3.2. Construction Preparation

Micro pile foundation construction preparations cover many aspects such as technology preparation, personnel preparation, construction machinery and tools, site preparation, micro pile equipment. These preparations are the first condition for the micro pile construction process.

3.3. Pore Forming

Hole forming of micro-pile foundation is a key link in pile foundation construction. The following are the main steps for hole formation:

(1) Determine the location of the hole: Determine the location of the micro pile according to the design requirements and position it (figure 8).

Figure 8. Pile hole positioning diagram.

Figure 9. Drilling diagram.

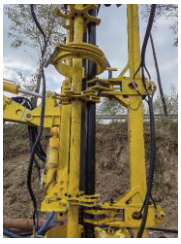

Figure 10. Post diagram.

Figure 11. Hole depth measurement diagram.

Equip with corresponding drilling tools: The appropriate drilling tools, including down-hole drilling, rotary drilling and spiral drilling, according to the designed pile diameter and geological conditions should be selected as the drilling tools.

(3) Start drilling (figure 9): Start the drilling rig, drill slowly, and keep entering the hole vertically. During the drilling process, pay attention to whether the drill pipe is offset. If there is any offset, it should be dealt with in time.

(4) Drill pipe connection (figure 10): When the stroke of one drill pipe ends, it is necessary to connect the next drill pipe and then continue drilling. When changing the

drill pipe, make sure the drill bit is firmly fixed to prevent the drill bit from falling into the hole.

(5) Depth confirmation (figure 11): Carry out drilling and depth measurement until the designed depth is reached.

3.4. Cleaning Operation

This step is our contribution. After the hole forming operation, hole cleaning operation needs to be carried out. The following is the two methods for cleaning different hole.

For dry hole, the hole can be cleaned directly through the micro pile drilling rig itself. The drill bit air pressure is used to blow out the drilling slag, and then the drill bit is lifted out of the hole for repeated blowing to complete the hole cleaning operation as shown in figure 12.

For wet hole, the barrel cleaning device is used to clean the holes. Firstly, air pressure will be used to blow the drilling slag into the barrel cleaning device. When the barrel cleaning device is full of slag, lift it up to clear out the drilling slag. Then dive the barrel cleaning device into the hole and repeat blowing and collecting slag, cleaning process to complete the hole cleaning operation as shown in figure 13.

As the contribution part, the hole cleaning operation also facilitates the staff to check the quality of the hole wall and the degree of cleaning of the hole bottom and the accuracy of the pile holes to avoid safety accidents caused by the presence of debris in the pile holes during the pouring process.

Figure 12. Dry hole cleaning diagram.

Figure 13. Wet hole cleaning diagram.

3.5. Steel Cage Installation

The installation process of steel cage mainly includes the following steps:

(1) Steel cage production: According to the design drawings, make a steel cage that meets the specified size, shape and strength.

(2) Transportation of the steel cage: Use a crane or other equipment to transport the prepared steel cage to the designated location. Care must be taken to avoid deformation or damage to the steel cage during the transportation process.

(3) Placement of the steel cage (figure 14): When placing the steel cage in the hole, use a pile driver or crane to slowly and vertically place the steel cage into the hole to prevent collision with the hole wall. If the steel cage cannot sink, the steel cage should be lifted out, clean the debris in the hole, and then place it again.

Figure 14. Rebar cage placement diagram.

Figure 15. Concrete pouring diagram.

(3) Confirm the location of the steel cage: After the steel cage is placed, verify whether its position and depth meet the design requirements. If there is a deviation, it needs to be adjusted immediately.

(4) Fixation of steel cage: After the steel cage is placed in place, it should be fixed immediately to prevent it from moving during the grouting process.

3.6. Concrete Pouring

The micro pile concrete pouring process mainly includes the following steps [9]:

(1) Check the pile hole quality in advance: including hole diameter, hole depth, virtual soil thickness at the bottom of the hole, etc., to ensure that the design requirements are met before concrete pouring can be carried out.

(2) Production of concrete test blocks: A set of test blocks should be made for each micropile to test the quality of concrete.

(3) Pay attention to the concrete temperature: In winter, the concrete temperature must not be lower than 3 degrees Celsius and insulation measures are required. In summer, when the concrete temperature is too high, a retardant needs to be added.

(4) Continuous pouring of concrete (figure 15): Concrete needs to be poured continuously during the pouring process to avoid excessive drop. Use conduits for pouring and vibrate and compact after pouring.

(5) Monitor the concrete liquid level: The height of the concrete liquid level is measured with a measuring hammer or buoy.

(6) Pile top concrete treatment: After the pouring is completed, the pile top concrete elevation should be slightly higher than the design elevation to ensure the pile top concrete quality.

(7) Pull out the casing: After the concrete pouring is completed, the casing should be pulled out from the pile hole immediately to prevent the concrete from bonding with it.

(8) Record construction information: Concrete usage, pouring time and other information need to be recorded in detail to facilitate continued inspection and management.

3.7. Maintenance and Mold Removal

After the construction of the micro pile foundation is completed, curing is required to ensure that the concrete has sufficient strength and durability [10]. Maintenance usually includes hardening period to ensure good hardening conditions, protection to be

protected from adverse weather conditions. Then, the timing of formwork removal should be carried out after the concrete strength reaches the design requirements, usually within a few days after the curing is completed. Deformwork for micropiles is usually simpler because they typically use recyclable steel formwork. Here are including inspection, formwork removal and cleaning.

4. Conclusions

The mountain micro pile drilling rig plays an important role in the construction of transmission lines. Its unique design can adapt to various complex mountain terrains, which brings great convenience to construction.

As a lightweight pile foundation, micro pile foundation has the advantages of small pile diameter, small required working area, small digging torque, high bearing capacity, and small square footage, which is conducive to environmental protection. By using the construction technology of micro-pile foundation, project construction can be completed more efficiently. The operated process can effective ensure quality of drilling hole and improve efficiency of project.

Looking to the future, this process will further optimize and improve to expand its application scope and achieve more efficient and environmentally friendly construction.

Acknowledgement

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