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Research on Pile Foundation Testing Technology for Building Construction Engineering

Ming Yu*

Institute of Geological Hazard Investigation and Monitoring of Hunan Province, Changsha, Hunan Province, 410000, China.

***Correspondence to:** Ming Yu, Institute of Geological Hazard Investigation and Monitoring of Hunan Province, Changsha, Hunan Province, 410000, China; Email: 1214752691@qq.com

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Abstract: Pile foundation testing technology for construction engineering is an important measure to ensure the quality and safety of pile foundations. In this paper, several common methods for pile foundation testing are introduced, including static load test method, core drilling method, low-strain method and rock foundation plate load test method. This paper also expounds on their respective characteristics and scopes of application. Meanwhile, the practical application of pile foundation testing technology in construction engineering is discussed as well, including determining the bearing capacity of pile foundation, detecting the integrity of pile foundation, and finding yet solving pile foundation quality defects.

Keywords: Construction engineering; Pile foundation inspection; Technology

Introduction

With the rapid development of urban construction and construction engineering, pile foundation, as an important part of construction engineering, makes its quality and stability rather important for the safety and durability of the project. In order to ensure that the quality of pile foundation meets the designated requirements, pile foundation testing technology has always been a research hot-spot in the field of construction engineering. Pile foundation testing technology can detect and solve pile foundation quality defects as early as possible and improve the quality and safety of the project by monitoring and evaluating the quality, deformation and bearing capacity and other parameters of the pile foundation in real time.

1. Overview of Pile Foundation Testing Technology

Pile foundation testing technology refers to a series of technical methods and means for examining, evaluating and monitoring pile foundation in construction engineering. Pile foundation is an important supporting structure of the building, which bears huge loads, and its quality and stability directly affect the safety and service life of the entire building. In pile foundation inspection technology, the most common method is

the static load test. The static load test refers to the application of a gradually increasing static load on the pile foundation, and the bearing capacity and deformation performance of the pile foundation are evaluated by measuring the relationship between the load and the deformation of the pile body. The static load test can judge the vertical stability and load transfer performance of the pile foundation, which is a reliable testing method. There is also a non-destructive testing technique for the inspection of pile foundations. Non-destructive testing evaluates the pile foundation's quality and performance by analyzing signals like acoustic waves, electromagnetic waves, displacement, and pressure around the pile, without causing damage to it. Non-destructive testing technologies include ultrasonic testing, resistivity method, acoustic wave reflection method, etc., which are widely used in the testing and evaluation of pile foundations. It is worth noting that different pile foundation testing techniques have their own advantages and disadvantages [1]. Static load testing is an intuitive and reliable method that requires on-site testing and is expensive, dynamic trigger testing is a fast, non-invasive method that requires high test conditions, and non-destructive testing is a non-destructive, remote testing method that often requires high equipment and expertise. With the development and innovation of science and technology, pile foundation testing technology is constantly updated and improved, which provides a more accurate and reliable basis for the design and construction of construction engineering.

2. Pile Foundation Testing Technologies

2.1. Static Load Test Method

The static load test method in pile foundation testing technology is a commonly used testing method to determine the bearing capacity and settlement of pile foundation. The static load test method is to observe the settlement of the pile by applying pressure on the top of the pile to determine the bearing capacity and settlement of the pile foundation. The static load test method usually adopts methods such as the anchor pile method and the stacking method, which is one of the more commonly used methods compared to the others. In the anchor pile method, a plurality of anchor piles are fixed in the soil around the pile foundation, and then the loading device is connected to the anchor pile, and the pressure on the pile foundation is applied through the loading device to observe the settlement of the pile body. The advantages of the static load test method include: it can directly measure the bearing capacity and settlement of the pile foundation, which has high accuracy and reliability, can simulate the actual load situation and detect the performance of the pile foundation under the actual use conditions, and can detect the response of the pile foundation under different loads, which has a good effect on the pile foundation testing under complex load conditions. However, there are also some shortcomings in the static load test method: such as the test period is long, a lot of manpower and material resources are required, and for some special geological conditions and complex structural forms of pile foundation, the test is difficult; therefore, when carrying out pile foundation testing, it is necessary to select the appropriate testing method according to the specific situation, and comprehensively consider the factors such as test period, manpower and material input, test accuracy, etc. At the same time, it is necessary to pay attention to safety issues during the test to ensure the reliability of the test.

2.2. Core Drilling Method

Pile foundation inspection technology is a very important section of work in construction engineering, which can ensure the stability and safety of buildings. The core drilling method is a commonly used pile foundation testing method, and its basic principle is to obtain information about the quality of the pile foundation through drilling and sampling, including the concrete strength of the pile body, the thickness of the sediment at the bottom of the pile and the integrity of the pile body. When performing a core drill inspection, it is necessary to determine the location and depth of the borehole. In general, the drilling location should be selected in the center of the pile foundation to ensure the accuracy of sampling. The drilling depth needs to be determined on a case-by-case basis, and it is generally recommended that the drilling depth should exceed three times the diameter of the pile foundation. During the drilling process, it is necessary to pay attention to maintaining the stability of the hole wall to avoid collapse. It is also necessary to use the appropriate drill bit and coolant to ensure the quality of the sampling. Once the sampling is complete, the samples need to be processed and analyzed to obtain

the required information. The advantage of the core drilling method is that it can intuitively understand the situation inside the pile foundation, and the testing results are accurate and reliable. However, this method also has some disadvantages, such as it can cause certain damage to the pile foundation, and the operation process is more complicated. Therefore, the suitability and safety of pile foundation inspection using the core drilling method need to be carefully considered.

2.3. Low-strain Method On-site Testing Technology

The low strain method is a commonly used pile integrity testing technology, which mainly uses a low-energy transient or steady-state method to excite at the top of the pile, measure the velocity time history curve of the top of the pile, or measure the force time history curve of the top of the pile at the same time as the measured speed and time history curve of the top of the pile. The integrity of the pile is assessed through time-domain or frequency-domain analysis based on wave theory. This technique is suitable for 1D linear elastic member models, including concrete cast-in-place piles, steel pipe piles. The testing principle of the low-strain method is based on the theory of elastic mechanics, that is, the displacement of a certain local position is measured, and the deformation of the entire pile is indirectly inferred. In practice, by installing multiple deformation sensors, the deformation distribution of the entire pile can be obtained. The low strain method is mainly divided into two specific application methods: one is the use of wire measurement method, that is, the sensor and the data acquisition equipment are connected through the wire to monitor and record the pile displacement data in real time, and the other is the use of wireless measurement method, that is, the wireless transmission technology is used to connect the sensor with the data acquisition equipment to achieve real-time data transmission and online analysis. The low strain method has high accuracy and sensitivity, which can monitor the small deformation of the pile in real time, and can accurately evaluate the deformation performance of the pile foundation [2]. It is a non-destructive testing method, which does not require destructive transformation of the pile and does not produce secondary engineering. The low-strain method is simple to operate and is suitable for all types of pile foundations, whether it is a new pile foundation or an existing pile foundation. As a commonly used on-site pile foundation testing technology, the low strain method can evaluate the quality and deformation performance of the pile foundation by monitoring the small deformation of the pile body. It has the characteristics of simplicity, high precision and non-destructiveness, but it needs to fully consider various factors when using, carry out data processing and comprehensive evaluation to achieve the purpose of accurate evaluation of pile foundation.

2.4. Sonic Transmission Method

Acoustic transmission method is a commonly used pile foundation testing technology, which mainly transmits and receives sound waves between embedded acoustic tubes, and detects the relative changes of acoustic parameters such as sound time, frequency and amplitude attenuation of sound waves propagating in concrete medium. The acoustic transmission method can detect the segregation, cracks, cavities and other problems inside the pile foundation, which provides an important basis for the quality evaluation and maintenance of the pile foundation. The principle of the acoustic transmission method is based on the characteristics of sound waves propagating in different media. When sound waves propagate from one medium to another, phenomena such as reflection, refraction, and transmission occur, which are related to the physical properties and boundary conditions of the medium. In pile foundation testing, the acoustic transmission method mainly detects the propagation and reflection of sound waves inside the pile foundation by sending sound wave signals at the pile foundation measurement point to determine the defects and foreign objects inside the pile foundation. In practice, acoustic transmission methods are typically measured using sensors and data acquisition devices. Sensors, placed in acoustic tubes within the pile foundation, capture and convert acoustic wave signals into electrical outputs. The data acquisition device then collects the signals output from the sensors and analyzes and processes them to evaluate the quality and defects inside the pile foundation.

2.5. Sintered Plate Loading Test

Sintered Plate Loading Test is a commonly used pile foundation testing technique, which evaluates the bearing capacity and stability of pile foundation by applying load to the rock foundation and measuring

parameters such as rock deformation and reaction force. The load test of rock foundation slab is widely used in independent foundation, raft foundation and other engineering, which provides an important basis for engineering design and construction. The principle of the load test of rock foundation slab is based on the theory of elastic mechanics and the principle of soil mechanics. In the test, a plate loader is first installed on the rock foundation and a gradually increasing vertical load is applied. The rock foundation is deformed under load, and the bearing capacity of the foundation can be evaluated by measuring the size and distribution of the deformation. At the same time, by measuring parameters such as reaction force and displacement, parameters such as stress, elastic modulus and deformation characteristics of the foundation can be calculated. It is important to clean and trim the rock foundation's surface, ensuring proper contact with the loader. The loader is then mounted on the surface of the rock foundation and connected to the data acquisition system. Gradually increasing loads are applied, and parameters such as deformation and reaction forces of the rock foundation are measured. Based on the measurement data, analyses and calculations are carried out to evaluate the bearing capacity and stability of the foundation.

3. The Practical Application of Pile Foundation Testing Technology in Construction Engineering

3.1. Inspection of the Bearing Capacity of the Pile Foundation

The application of building pile foundation testing technology in engineering is very important, and determining the bearing capacity of pile foundation is one of the important links of testing. The bearing capacity of the pile foundation refers to the maximum load that the pile foundation can bear in the static load test, which plays a vital role in the safety and stability of the pile foundation. In engineering, the methods for determining the bearing capacity of pile foundation include static load test method and pile foundation testing method. Among them, the static load test method is one of the most commonly used methods, which applies pressure on the top of the pile and observes the settlement of the pile to determine the bearing capacity and settlement of the pile foundation. The pile foundation testing methods include low strain method and high strain method, etc., and different information of pile foundation can be obtained through different testing methods, such as the integrity of pile foundation, defect location and pile length. When carrying out pile foundation testing, it is necessary to select the appropriate testing method according to the specific situation, and comprehensively consider the test cycle, manpower and material input, test accuracy and other factors. At the same time, it is necessary to pay attention to safety issues during the test to ensure the reliability of the test. When determining the bearing capacity of the pile foundation, select the appropriate loading device and loading mode to ensure the accuracy of the test; It is necessary to select appropriate settlement observation points to obtain more accurate settlement data; The test data is processed and analyzed to produce accurate test results. When determining the bearing capacity of pile foundation, it is necessary to choose an appropriate testing method and pay attention to the accuracy and reliability of the test. At the same time, the processing and analysis of test results also need to be taken seriously in order to obtain accurate test results.

3.2. Inspection of the Integrity of the Pile Foundation

Building pile foundation testing technology is widely used in engineering, and the testing of pile foundation integrity is one of the important ones. The integrity of the pile foundation is directly related to the stability and safety of the building, so it is necessary to inspect it. At present, the commonly used pile foundation integrity testing methods include low strain reflection wave method, ultrasonic transmission method, core sampling method, etc. The low strain reflection wave method is a non-destructive testing method that uses the propagation of the stress wave in the pile to determine the integrity of the pile foundation by applying an impact force to the top of the pile.

The ultrasonic transmission method is to judge the integrity of the pile foundation by emitting ultrasonic waves into the pile, and using the propagation speed and reflection of the ultrasonic waves in the pile [3]. The core sampling method is to take out the pile sample by drilling a hole for laboratory analysis to judge the integrity of the pile foundation. Each of these methods has its own advantages and disadvantages, and the

appropriate method for testing needs to be selected on a case-by-case basis. Regardless of the method, the accuracy and reliability of the test need to be guaranteed. At the same time, it is also necessary to pay attention to safety issues when carrying out pile foundation integrity testing to avoid causing harm to personnel and equipment. The application of building pile foundation testing technology in engineering is very important, and testing the integrity of pile foundation is one of the key steps. Only by ensuring the integrity of the pile foundation can the stability and safety of the building be guaranteed.

3.3. The Detection and Solution of Pile Foundation Quality Defects

The application of building pile foundation testing technology in engineering also includes finding and solving pile foundation quality defects. Pile foundation quality defects refer to the problems that occur in the construction process of pile foundation, such as pile fracture, pile segregation, necking, and excessive thickness of pile bottom sediment. These defects will affect the bearing capacity and stability of the pile foundation, so they need to be discovered in time and taken measures to solve them. In engineering, the methods for finding and solving pile foundation quality defects include static load test, low strain, core drilling method, acoustic transmission method, etc. After discovering the quality defects of the pile foundation, it is necessary to take measures to solve them in time. Common solutions include reinforcing the pile foundation, repairing defective parts, reconstruction, etc. For some larger defects, a variety of measures may need to be taken for comprehensive management.

Conclusion

This study of pile foundation testing technology in construction engineering deepens our understanding of evaluating pile foundation quality and stability. Continuous improvement and innovation of testing technology, combined with a variety of methods to verify each other, can improve the accuracy and reliability of pile foundation testing. Future research directions include the development of more advanced non-destructive testing techniques and data analysis methods to achieve more efficient and accurate pile foundation inspection. The continuous development of pile foundation testing technology for construction engineering will provide important technical support and guarantee for engineering construction.

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