

Study on Quality Control Measures of Bored Pile in Highway Bridge Construction

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Abstract: Quality control of bored pile is crucial to the safety and durability of the whole project. This study proposes corresponding control measures for the main quality problems existing in the construction process of bored pile, including site preparation, drilling construction, steel cage production, concrete pouring and other links. Effective quality control measures can significantly improve the overall quality of bored pile, to ensure the safety and durability of highway bridge engineering.

Keywords: Highway Bridge; Bored Pile; Quality Control; Site Preparation; Concrete Placement

1. Introduction

The safety and durability of highway bridge engineering are directly related to the smooth flow and efficiency of transportation, so the foundation treatment link is particularly important. As a common foundation treatment process, bored pile is widely used in highway bridge construction. However, due to the complex construction process and many links, the quality control of bored pile faces many challenges. The following will deeply discuss the main quality problems in the construction of bored pile and put forward the corresponding control measures to provide a strong guarantee for the smooth implementation of highway bridge projects.

2. Site Preparation and Drilling Construction Control

2.1 Site Leveling and Measurement Lofting

Site leveling is a prerequisite for the construction of bored pile, which requires thorough cleaning of the ground of the construction site, removing all kinds of debris, construction waste and obstacles to ensure that

the site is smooth and tidy, and necessary earthwork leveling and compaction treatment of the site to achieve sufficient bearing capacity and avoid uneven settlement and other problems in subsequent construction. Measurement lofting is a very key link in the construction of bored pile, which directly affects the accuracy of pile position. According to the engineering design drawings, advanced measuring equipment such as theodolite and total station are used to accurately mark the position and elevation of each pile position. When measuring lofting, relevant specifications should be strictly implemented to ensure the measurement accuracy. At the same time, it is also necessary to set obvious marks so that the pile position can be quickly and accurately located during subsequent construction. The quality of the measurement lofting is directly related to the accuracy and quality of the entire project, so it must be attached great importance.

2.2 Drilling Quality Control

Drilling construction is a crucial link of bored pile, which requires strict control of the verticality of the drilling to ensure that there is no deviation or tilt in the drilling process. Auxiliary equipment such as pilot hole guide device and laser vertical controller can be used to monitor and adjust the verticality of the drilling in real time, and at the same time strictly control the aperture of the drilling to make it meet the design requirements. Neither too much waste of concrete nor too little affect the subsequent construction, but also need to pay close attention to the depth of drilling to ensure that the drilling depth meets the design requirements. In the process of drilling, it is also necessary to clean the bottom of the hole in time to prevent the quality problems caused by residual drilling slag, mud or groundwater. Manual cleaning or mechanical cleaning can be used to completely remove the debris at the

bottom of the hole. According to the actual geological conditions, it is also necessary to take corresponding remedial measures such as wall protection in the encounter of quicksand or hole collapse, filling cement slurry to ensure the smooth progress of drilling.[1]

3. Steel Cage Production and Concrete Placement Control

3.1 Steel Cage Production Quality Control

The quality of the steel cage is one of the key factors to ensure the bearing capacity of the bored pile, so the quality control of the steel cage production is crucial, first of all, it is necessary to ensure the quality of the steel bar, the steel bar must be tested and qualified products and meet the strength level of the design requirements, while the surface of the steel bar is no rust, no pollution, and it needs to be thoroughly cleaned up before use. Then is the quality control of steel bar processing and binding, the size of the steel bar must be processed in strict accordance with the design size, cutting and bending operation specifications, the use of professional tools to ensure the dimensional accuracy and strictly implement the design requirements of the bar distance, the thickness of the protective layer, etc., the use of qualified steel strand binding firmly, smooth and uniform, to ensure the overall strength and stiffness of the steel cage. When installing the steel cage, it is necessary to first place the bottom steel bar and make a good cushion with plastic pipes, and then lift the main cage and shear cage section by section and connect them reliably, and finally form a complete steel cage skeleton. At the same time, it is necessary to install the auxiliary facilities such as waveguide and protection pipe and strictly control the size requirements such as location and burial depth. After the steel cage is completed, professionals need to be organized to strictly check whether the shape, size, strength, etc. meet the requirements and do a good job of quality records and visas. Only by ensuring that the steel cage meets the quality requirements can we lay a good foundation for the subsequent concrete pouring.[2]

3.2 Quality Control of Concrete Placement

Concrete placement is the last key process of bored pile construction, which first needs to ensure the quality of raw materials, the cement,

coarse aggregate, admixture used must pass the inspection and meet the design requirements. Then, the appropriate mix ratio should be determined according to the specific conditions of the project and the results of the on-site trial mix, and various mix ratio indicators such as dry powder content, slump, workability and other properties should be strictly controlled to meet the requirements. When mixing concrete, various raw materials should be measured separately and mixed evenly, and slump and slump direction should be tested for each batch of concrete. Concrete is transported by concrete tank truck or pump truck to ensure that no segregation, bleeding and other phenomena affect the quality of concrete during transportation. Concrete placement is carried out in a layered batch pipe jacking drill pipe funnel. The height of each layer is controlled within 0.5~1.0m to avoid excessive compaction. During the placement, attention should be paid to the concrete collapse and concrete compaction, and the placement method should be adjusted in time if any abnormality is found. After concrete pouring, in order to avoid the influence of water accumulation and siltation, it is necessary to clean the concrete residue at the opening in time, and check the initial setting time of concrete in time, and arrange the subsequent construction work reasonably according to the actual situation. After pouring, effective maintenance measures should be taken to ensure the strength and durability of concrete. Common maintenance measures include shading, heat insulation, spraying curing agent, covering insulation layer, etc. The entire pouring process requires professionals to strictly monitor and record various parameters such as temperature, slump, pouring height, etc. If abnormal conditions are found, corrective measures should be taken in time. After the concrete reaches the design strength, the next step of construction can be started. If necessary, the mechanical properties such as compressive resistance and impermeability should be tested, and the excellent performance of the pile concrete can be ensured through strict concrete placement control, laying a solid foundation for the safety and durability of the whole bridge project.

4. Foundation Pit Excavation and Pile Body Detection

4.1 Excavation and Pile Top Treatment

When the concrete reaches the design strength, it is necessary to excavate the foundation pit to prepare for the subsequent construction of the upper structure such as bridge piers and cover beams. During the excavation of the foundation pit, the excavation scope and depth should be strictly controlled to avoid damage or impact on the completed pile body. During the excavation, temporary support and drainage work should be arranged to ensure the safety of construction. In the process of excavation, if it is found that there are quality defects in the concrete of the top of the pile, such as honeycomb, rammed pulp, exposed reinforcement, etc., the part needs to be resected, and the depth of the resected part needs

to be determined according to the specific situation, generally controlled at about 1~2 meters. After resected, the top of the pile needs to be leveling treatment to ensure that the top of the pile is smooth and clean, and create good conditions for subsequent construction. In addition, it is also necessary to strengthen the pile top, such as adding arm plates and welding steel cages to improve the load bearing capacity and shear resistance of the pile top to meet the demand of the superstructure. The selection of reinforcement measures needs to be determined according to the specific situation and combined with the design requirements.[3]

Table 1. Quality Control Parameter Table of Bored Piles in Highway Bridge Construction

Parameter item	Standard value / range	test method
borehole diameter	1.2-1.5m	on-site measurement
drilling depth	≥ 20 m	depth calibrator
Verticality deviation	$\leq 0.5\%$	Laser oblique meter
Clean up the quality at the bottom of the hole	No obvious debris	visual inspection
Steel cage diameter	1.1-1.4m	Tape measure
Steel cage length	20.5m	Tape measure
Concrete slump	160-200mm	Decumpability measurement
strength grade of concrete	C30 or more	Pressure resistance strength test
curing temperature	5-35°C	thermometer
Pile top elevation deviation	± 10 mm	Full station meter measurement

4.2 Integrity Testing and Quality Assessment

After completion, it is necessary to conduct integrity testing on the pile body to confirm that there are no cracks, voids and other defects in the pile body to ensure the integrity of its structure and bearing capacity. Common testing methods include low strain detection method, drilling core sampling method, ultrasonic detection method, etc. Low strain detection method is a non-destructive testing method. The integrity of the pile can be judged by introducing the stress wave into the waveguide tube reserved outside the pile body and measuring the time and energy of the reflected wave. This method is simple and low-cost, but it can only provide qualitative judgment, and cannot determine the specific location and size of the defect. The core drilling sampling method is to drill concrete core samples in the center of the pile body for visual inspection and mechanical performance test, which can accurately evaluate the actual quality of the pile body. However, this method is a semi-destructive test, which will cause certain damage to the pile body, and the operation is

more complicated and the cost is higher. The ultrasonic detection rule is to analyze the defects inside the pile by transmitting and receiving ultrasonic signals through the transmission characteristics of ultrasonic waves in different media. This method is non-destructive and easy to operate, but it is greatly affected by factors such as pile materials and geometric size, so the detection accuracy has certain limitations. According to the test results, the quality of the pile body can be assessed to determine whether it meets the design requirements. For the pile body with defects but still within the acceptable range, appropriate reinforcement measures can be taken, while for the pile body with serious defects, it needs to be reworked or dismantled to ensure the overall quality and safety of the project. Integrity testing is the last quality checkpoint for the construction of bored pile. It is necessary to select the appropriate testing method, strictly implement the testing procedures and make an objective and fair assessment of the pile quality according to the testing results, so as to lay a solid foundation for the smooth delivery and use of the project.[4]

5. Testing Methods and Control of Construction Tools

5.1 Selection and Implementation of Detection Methods

The selection of appropriate testing methods is crucial for the accurate evaluation of pile quality, and the selection of testing methods should comprehensively consider many factors such as engineering characteristics, construction conditions and economic cost. The low-strain testing method is suitable for preliminary integrity testing of a large number of piles due to its simple operation and low cost, but it cannot quantitatively analyze the specific location and size of defects. Therefore, it is often necessary to combine with other detection methods. The core sampling rule can directly reflect the actual quality status inside the pile body, which is one of the most reliable and authoritative testing methods at present. However, this method is semi-destructive testing, which will cause certain damage to the pile body, and the operation is complicated and the cost is high, so it is usually only used in the case of critical pile body or quality disputes. Ultrasonic detection method has the characteristics of non-destructive, portable and efficient, which is suitable for rapid screening of a large number of piles. However, because this method is greatly affected by factors such as pile material and geometric size, the detection accuracy has certain limitations, and it is usually needed to be combined with other detection methods. When conducting testing, it is necessary to strictly abide by the relevant specifications and operation instructions to ensure the accuracy and reliability of the test data. The testing personnel should have the corresponding professional qualifications and experience to master the use of various testing equipment. At the same time, the testing equipment should be regularly calibrated and maintained to ensure that it is in good working condition. The collection, recording and analysis of test data also need to be extra careful to avoid mistakes or omissions. The piles with doubts about the test results should be reviewed in time or verified by other testing methods to ensure the accuracy of the assessment results.

5.2 Control of Construction Machinery and Equipment

The construction of bored pile requires the use

of a large number of machinery and equipment such as crawler drill, concrete pump truck, truck crane, vibrator, etc. The performance of these equipment determines the quality and efficiency of the construction, so it is necessary to implement strict control and management of construction machinery and equipment. On the one hand, reliable quality and advanced performance machinery and equipment should be selected to meet the requirements of construction operations. The equipment used must pass strict inspection and acceptance before it can be put into use. The equipment that has exceeded its service life or has potential safety hazards should be phased out and updated in time. On the other hand, special personnel should be designated to manage the use, maintenance and maintenance of the equipment, and detailed operation instructions should be formulated to standardize the operation process of the equipment and arrange corresponding training. Ensure that the operator is familiar with the use of the equipment. During the construction process, the safety operation procedures of the equipment should be strictly observed to prevent the occurrence of equipment failure or safety accidents caused by improper operation. The equipment should be inspected and maintained daily to ensure that it is in good working condition. If the equipment is found to have faults or abnormal conditions, the causes should be timely investigated and properly handled to avoid delay in construction period or affect the construction quality. It is also very important to strictly implement the regular testing and annual inspection system of the equipment, and the testing should be implemented by institutions or personnel with corresponding qualifications, and the equipment should be rated according to the test results, and the hidden dangers should be eliminated in time for the unqualified equipment to ensure that the equipment is in a safe and reliable state.[5]

6. Personnel Quality and Construction Environment Control

6.1 Quality Control of Construction Personnel

The comprehensive quality of construction personnel is crucial to the control of the construction quality of bored pile. Both project management personnel and front-line operators need to have the corresponding professional

knowledge, skill level and professional ethics to ensure the standardization and standardization of various construction operations. Construction units must attach great importance to the training and training of personnel. Through regular organization of technical disclosure, safety education, standard publicity, operation drills and other forms to continuously improve the professional skills and safety awareness of operators, so that they can master each process of bored pile construction, understand the relevant technical standards and operating norms, and strengthen the training of project management personnel to enhance their management ability and comprehensive quality. So that it can scientifically formulate the construction scheme, strictly control the construction quality, optimize the construction organization. It is very important to establish and improve the corresponding personnel assessment mechanism. Personnel in key positions such as rig operators, concrete workers, welders, etc. shall be subject to qualification review and certificate entry system to ensure that they have the appropriate operational skills. Personnel without licenses or with substandard skills shall not enter the post. At the same time, it is necessary to establish a sound performance appraisal system to include quality control, safety production and civilized construction into the scope of assessment, reward those who perform well, and seriously deal with those who violate rules and regulations. Only when the comprehensive quality of construction personnel is comprehensively improved, all operations in the construction of bored pile can truly comply with regulations, standards and norms. Lay a solid foundation of human resources for the control of engineering quality.

6.2 Control of Construction Environmental Conditions

Control and optimization of construction environmental conditions are crucial to the quality and progress of bored pile construction. It is necessary to take a number of measures to ensure the suitability of construction environment. Reasonable arrangement of construction plan and operation time is the first step, which requires avoiding adverse weather conditions such as high temperature, cold and heavy rain as far as possible to avoid adverse effects on construction quality. For the inevitable bad weather, it is necessary to take

corresponding protective measures such as shading, anti-freezing, anti-seepage, etc., to create good environmental conditions for construction operations. Then it is necessary to strengthen the environmental management of the construction site, keep the site clean and orderly, prevent all kinds of debris, mud and other pollution of the site environment, and also need to carry out the necessary drainage and enclosure treatment on the construction site to avoid groundwater leakage or site water impact on the construction quality. Attention to the control of construction noise is also the key, which can take effective noise reduction measures such as the use of low noise equipment, install noise reduction devices to reduce the impact of noise on the surrounding environment, and maintain a good construction environment. In addition, for some special construction environment such as slope, water area, etc., it is necessary to take corresponding protection and reinforcement measures to ensure the safety and quality of construction operations. Scientific and reasonable control and optimization of construction environmental conditions is an important prerequisite to ensure the construction quality of bored pile.

7. Conclusion

This study puts forward comprehensive control measures for the main quality problems in the construction process of bored pile, including site preparation, steel cage production, concrete pouring, foundation pit excavation, pile body detection, detection method selection, construction machinery control, personnel quality improvement and construction environment control, covering all key links of bored pile construction. Strict implementation of these control measures can effectively improve the overall quality of bored pile, ensure the safety and durability of highway bridge engineering, and play an important role in the smooth transportation.

References

- [1] SHI Xiaohui. Application of bored pile construction Technology in Highway Bridge construction [J].Transportation Manager World,2023,(30):98-100.
- [2] Yang Lei. Discussion on construction quality control of bored pile in Highway Bridge construction [J].Transportation World,2022,(21):66-69.

- [3] WANG Mingzhe. Analysis on the application of bored pile construction technology in Highway Bridge construction [J]. Science and Technology Innovation, 2022, (20): 109-112.
- [4] JIA Xiaoliang. Probe into quality control Measures of bored pile in Highway Bridge construction [J]. Metallurgical Management, 2021, (17): 134-135.
- [5] MA Guopeng. Quality control analysis of bored pile in Highway Bridge construction [J]. Smart City, 2021, 7(06): 138-139.