

Research on Pollution Prevention and Control Technology for Bored Pile Construction

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Abstract: *Bored pile construction is a widely adopted foundation technique in civil engineering, valued for its adaptability to complex geological conditions and its capacity to support heavy structural loads. However, the construction process generates significant environmental impacts, including the discharge of large volumes of drilling slurry, noise pollution from heavy machinery, vibration disturbances, and the potential contamination of surrounding soil and groundwater. These environmental risks pose challenges to sustainable construction practices and regulatory compliance, necessitating the development and implementation of effective pollution prevention and control technologies. This research focuses on the systematic investigation of pollution control strategies specifically tailored to bored pile construction. The study examines the sources and characteristics of major pollutants generated during various stages of construction, including drilling, slurry circulation, and concrete pouring. Based on a comprehensive review of existing technologies and field observations, the research evaluates the performance of key control measures such as slurry treatment and recycling systems, closed-loop circulation techniques, noise reduction equipment, and sedimentation pond design. Additionally, the study explores the integration of real-time monitoring technologies and digital management platforms to enhance the precision and responsiveness of pollution control efforts. The findings indicate that a combination of technological innovation, rigorous on-site management, and adherence to environmental standards can substantially reduce the ecological footprint of bored pile construction. This research provides practical guidance for engineering practitioners and contributes to the broader goal of promoting environmentally responsible practices in foundation engineering.*

Keywords: Bored pile; Pollution prevention; Mud casing.

1. INTRODUCTION

Mud plays a crucial role in bored pile construction, as it can effectively form a mud cake on the hole wall, which protects the well wall and prevents leakage. However, the waste mud after construction has always been a problem plaguing construction. Currently, the commonly used disposal method is to randomly build open-air mud pools and discharge the mud into them to dry naturally. This treatment method is primitive and backward, causing significant environmental pollution. In response to this, this paper explores through experiments the installation of a multi-functional steel mud casing on the borehole for temporary storage, sedimentation, and convenient transportation to the mixing station for centralized treatment.

The construction area of the bridge bored piles in this experiment is located in the central area of the Litang Basin, passing through the key environmental protection area of Litang Grassland. The route is mainly dominated by hilly plateau and mountainous landforms, with an average operating surface altitude of 4000m. The geological overburden is thick, and the lithology is mainly Quaternary soil, primarily Holocene alluvial-diluvial silty soil, etc. The water level is high, and the overall area is in the water level fluctuation zone. The freeze-thaw environment is D3, and the maximum freezing depth of deep-freeze seasonal frozen soil is 1m. According to the standard penetration test calculations for the sand layers revealed by drilling, there is local sand liquefaction.

The length of the bridge bored piles is 54-67m. Since the project is located in the Litang Grassland, there are high requirements for environmental and water protection. The on-site turf should be minimized from damage, and the original landform should be minimized from pollution. For this reason, the previously used earthen pit mud pools were avoided for the bridge bored piles, and a complete set of mud circulation systems was adopted, including centralized mud making at the mixing station, steel mud pools, drill cuttings boxes, mud pumps, sand separators, and orifice anti-overflow casing platforms. Through the construction practice of pollution prevention in this experimental bored pile construction, the construction technology is summarized to meet the local environmental and water protection requirements.

2. MAIN PROCESS PRINCIPLES

At present, the construction of bored piles for railway bridges generally adopts temporary excavation of mud troughs and mud pools for mud circulation. During construction, a large amount of earthwork is required, a large amount of site floor space is needed, it is difficult to restore the original state after construction, and if a large amount of drilling fluid mud formed during the excavation process is not treated in time, it will also cause significant environmental protection problems. This paper discusses how to reduce pollution during the construction process. For this purpose, rotary drilling rigs with less pollution are preferred for construction. A mud mixing tank is set up at the mixing station for centralized mud mixing. The mud mixing tank is coated with waterproof paint to ensure no leakage. The prepared mud is transported to the site by mud transport vehicles; At the construction site, a steel casing to prevent overflow at the orifice, a steel mud tank and a drill slag tank are set up. Mud is centrally stored and recycled. A mud baffle is placed between the drill bit and the slag tank to prevent mud from spilling; After the mud flows back to the mud tank, a sand separator is used to separate the sand in the mud to ensure that the sand content meets the requirements and increase the mud recycling rate; After multiple cycles of use, the waste mud is transported to the mixing station and treated with sewage treatment equipment to separate mud and water. The separated water is recycled, and the mud cake is transported to the designated slag disposal site. Finally, the treated waste mud is discharged into the sewage channel.

3. OPERATION POINTS

3.1 Preparation of Mud

3.1.1 Preparation of Mud

Centralized mud preparation at the mixing station is adopted. High-quality clay is selected for mud making, and an appropriate amount of admixtures can be added to stabilize the mud performance. The test engineer is responsible for the mud mix ratio test and mud preparation. The tentative mud mix ratio is: water: clay: bentonite = 1:0.4:0.08 (mass ratio). The laboratory tests the mud indicators every 3 hours.

3.1.2 Mud Transportation

The prepared mud is transported to the site by a mud transport vehicle.

3.1.3 Mud Tank Setup

Mud circulation and purification are achieved using steel mud tanks, mud separators, and rod pumps. The mud tanks are divided into sedimentation tanks, storage tanks, and mixing tanks. A rod pump is installed at the orifice of the bored pile to pump mud from the hole into the mud tanks. The mud separator filters out sand, and the mud then enters the drill pipe through the circulation tank to complete the cycle. During the bored pile construction, the mud and sediment in the multi-functional mud sedimentation tank shall be cleaned up at any time to strictly prevent mud overflow. The temporary drilling slag storage tank is used during the drilling process to temporarily store the mud overflowed when the drill bit is lowered, preventing mud overflow and waste, as well as environmental pollution. When the drilling rig lifts the drill bit to discharge slag, the mud stored in the mud jacket box can be timely supplemented into the hole to ensure the mud volume in the hole and prevent problems such as hole collapse and diameter reduction caused by insufficient mud. The casing is located in the storage tank. During the drilling process of the rig, the storage tank effectively protects against soil loss around the casing, surface water scouring, mud leakage, etc., and prevents casing deviation and settlement.

A working platform and protective mesh are set up on the upper part of the orifice to ensure the construction safety of the bored pile during the whole process, including orifice observation during drilling, pile position re-measurement, hole formation acceptance, reinforcement cage lowering, concrete pouring, and orifice protection during the process interval. It also improves work efficiency and construction quality to a certain extent.

A mud pump bracket is installed at one corner of the platform to facilitate the placement of the mud pump. During the pouring process, especially during the first batch of bottom sealing, the mud overflows in a large amount in a short time, and the mud pump can pump and discharge it in time, with a particularly obvious effect of preventing overflow.

The protection piles are used to check the accuracy of the casing, ensure that the deviation of the pile position meets the requirements, and ensure the alignment accuracy of subsequent drilling and lowering of the

reinforcement cage. Based on the simple geometric principles that two points determine a straight line and two non-parallel straight lines must intersect at a point, the cross equidistant quantitative control method is adopted to embed the protection piles.

3.1.4 Drilling Slag Box Setup

Each rotary drilling rig is equipped with a temporary drilling slag box, placed adjacent to the multi-functional mud box, for temporary slag storage to reduce mud overflow during the process. After being filled, the slag box is lifted by a crane onto a flatbed truck and transported to the centralized drying area. After drying, it is transported to the slag yard using a closed slag truck. The platform of the multi-functional steel casing for bored piles is a rectangular prism with structural dimensions $3.0 \times 4.0 \times 0.55$ m (length \times width \times height), made of 6mm steel plates and angle steel. The bottom of the platform is an opening according to the pile type and casing diameter, with the opening size approximately 10cm larger than the casing diameter. A mud circulation pump is placed on the side away from the hole mouth. A working platform and protective mesh are built above the hole mouth using angle steel and $\Phi 20$ steel bars, and four protective piles are set at the four sides of the platform.

3.1.5 Use of mud-sand separator

A mud-sand separator is installed at the mixing station to uniformly treat the mud from bridge pile foundations in the area, reducing the investment and transfer of mud separators. After the sewage suction truck pours the mud into the mud separator for separation, the separated sand particles are discharged into the sand trough outside the mud box, and the separated mud is discharged into the sedimentation tank. After three-stage sedimentation and water quality treatment, the clear water is discharged into the sewage channel. The sand particles and sediments are transported by a loader to a temporary storage site and finally uniformly transported to the spoil area for disposal.

3.2 Casing Platform

(1) The platform height is set to 50cm, flush with the casing, and the platform for standing on top should be larger than 50cm.

(2) The interior of the casing is for temporary storage of mud discharged from the hole, and a mud pump bracket is installed at one corner of the platform to facilitate the placement of the mud pump.

(3) Protective piles can be set at the four corners of the platform.

4 Benefit Analysis

This technical research solves the problem of pile formation construction of bored piles in key environmental protection areas, with advantages such as high equipment cost performance, low personnel input, high mechanization level, and the ability to implement day and night construction. It minimizes environmental pollution, improves work efficiency, and shortens the construction period.

This process reduces mechanical construction and earth excavation volume. Overall calculation shows that it reduces construction costs, saving 18,000 yuan compared with traditional processes, and the more recycling times, the higher the benefit. The process costs are shown in the table.

Table 1: Process Comparison Cost Table

Process Comparison	Item	Unit	Quantity	Unit Price (10,000 yuan)	Rental Period (days)	Cost (10,000 yuan)
One Set of "Zero Pollution" Mud Circulation System Equipment for Bored Pile Construction	Steel Mud Tank	piece	5	3	sheet	15
	Drilling Slag Box	piece	1	4	/	4
	Mud Pump	piece	2	0.2	/	0.4
	Sand Separator	piece	2	4.8	sheet	9.6
	Orifice Anti-Overflow Casing Platform	piece	1	2.8	sheet	2.8
	Total Cost					

Traditional Mud Pit Construction (Bridge as a Whole)	Mud Pit Excavation	piece	20	0.35	minute	7
	Mud Pit Earth Backfilling	piece	20	0.13	sheet	2.6
	Mud Pit Turf Restoration	piece	20	0.4	sheet	8
	Excavator	unit	2	0.4	20	16
	Total Cost					

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