ISSN: 2472-3703 DOI: 10.6911/WSRJ.202410_10(10).0006

Application and Effect Analysis of Shield Muck Slurry Separation Technology in Tunnel Construction

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Abstract

In the process of shield construction in urban rail transit construction, shield muck or mud with more water content may be produced. The particle size of shield muck is relatively small and in the flow plastic state, so there must be many difficulties in transportation. It is time-consuming and laborious to clean up the overflow of slurry in the process of residue transportation, and the cost of transportation and disposal is high. At present, engineers have put forward higher requirements for solving the problem of shield muck slurry separation technology. Taking the shield tunnel project between two stations of Chongqing Rail Transit Line 18 as an example, combined with the on-site soil conditions, through the investigation and analysis of the existing mud-water separation methods, the slag-soil-slurry separation equipment suitable for the site is selected and designed, so as to solve the problems of difficult transportation and abandonment of shield slag and environmental protection. At the same time, it can also provide some reference for the treatment of slag-soil slurry under this kind of characteristics in the future.

Keywords

Rail transit; Shield muck; Mud fluid; Sludge-water separation.

1. INTRODUCTION

Traffic congestion in some cities in China is becoming more and more serious. Especially in cities with rapid economic development, underground rail transit is needed to alleviate the traffic load on the ground. At present, the methods of building urban rail transit usually include open-cut method[1], underground excavation method[2]and hole-pile method. The advantages of the open cut method are simple construction, fast speed and relatively low cost. The disadvantage is that it has a great impact on the ground traffic and the surrounding environment. The underground excavation method is suitable for the situation where the surface buildings are dense or the surface conditions are not allowed to carry out open excavation, including the shield method[3], the drilling and blasting method[4]and so on. Shield method is suitable for underground construction with long distance and stable geological conditions. The shield machine can tunnel while lining, which can greatly reduce the impact on the ground. The drilling and blasting method is suitable for rock or other hard geological conditions, and controlled blasting is needed to ensure the minimum impact on the surrounding environment. Because the project is located below the downtown area of the city, and the surrounding rock is complex, the use of shield construction is the best choice, but the use of shield construction has to consider the abandonment of shield muck. If the shield construction

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202410_10(10).0006

in the water-rich stratum, it will inevitably produce a large amount of mud-water mixture. If not handled properly, it is not easy to transport in the process of transportation and also pollutes the road environment. How to use reasonable technology at low cost to separate the muck and water to meet the emission standards is the key to the problem, and it is also a kind of protection to the environment.

In this paper, by combining the existing shield muck slurry treatment technology, according to the actual situation of the field engineering case, the design of the muck slurry separation technology and the selection of equipment and parameters are introduced in detail. Finally, a low-cost, efficient and environmentally friendly technical scheme suitable for the actual situation of the site is designed.

2. PRESENT SITUATION OF SLUDGE WATER SEPARATION TECHNOLOGY OF SLAG SOIL

When the shield machine excavates the tunnel, it may produce a large amount of muck slurry, which usually contains a large amount of water and fine particles. It is necessary to separate the slurry to reduce the impact on the environment and improve the utilization rate of resources. The existing mainstream methods of shield muck slurry separation have the following categories: Using the combination of shield slurry and other materials as the grouting material at the back of segment lining[5]to realize waste utilization; By adding chemical flocculation or combining with mechanical method to make the solid-liquid separation of slurry; With reference to the oil drilling slurry treatment technology, the shield muck with mud water is solidified[6].The treated muck can be recycled[7].

The following are several slurry separation methods in engineering: ① Gravity sedimentation method: It is a traditional slurry separation technology, which mainly relies on gravity to achieve the separation of solid particles and water. By using the density difference between solid particles and water, under the condition of static or slow flow, the solid particles sink to the bottom under the action of gravity, while the upper layer is relatively clear water. This method is suitable for separating larger or denser particles. ②Centrifugal separation method: Centrifugal separation technology uses centrifugal force to separate the solid and liquid in the mud. The high-speed rotating centrifuge causes the slurry to be subjected to centrifugal force. The solid particles are thrown to the wall of the centrifuge because of their high density, and the liquid is discharged from the center. This technology has a good separation effect on fine particles. ③ Chemical flocculation precipitation method: Flocculation precipitation technology is to add flocculant to the mud, so that the fine suspended particles gather into larger flocs, and then separated by gravity precipitation or concentration equipment. This method can effectively improve the sedimentation rate of the solid in the mud and reduce the occupied area. ④ Pressure filtration separation method and belt pressure filtration separation method [8]: Pressure filtration separation technology is to apply pressure to the mud through the filter press, so that the water is discharged through the filter cloth, while the solid particles are intercepted on the filter cloth; the belt pressure filtration technology is to filter the mud through a continuously operating belt filter. The mud forms a filter cake on the belt, and applies pressure to the filter cake through the roller to squeeze out water. This technology is suitable for continuous production environment. This technology is suitable for the need to obtain dry solid particles. ⑤Filtration separation method: the technology of separating solid and liquid in muck slurry by using filter medium. This method intercepts solid particles by filtering media (such as filter screen, filter cloth or filter cake), and allows liquid to pass through, thereby achieving mud-water separation. ⑥Deep cone slurry separation method: The deep cone slurry separation technology uses a deep cone sedimentation tank or separation tank to improve the separation efficiency by increasing the precipitation time. After the mud enters the

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202410_10(10).0006

deep cone tank, the solid particles gradually sink due to gravity, and the water is discharged from the top. ⑦Vacuum dehydration method: it is a kind of vacuum technology to realize the separation of solid and liquid in muck slurry. This method is to use the negative pressure generated by the vacuum pump to reduce the pressure in the mud, so that the water is evaporated at a lower pressure or extracted through the filter medium, and the solid particles are retained on the filter medium to achieve mud-water separation.

These slurry separation technologies can be used alone or in combination in practical applications to achieve the best separation effect. The choice of technology depends on factors such as the nature of the mud, treatment requirements, and economic costs. Through effective mud-water separation, it can not only reduce the impact on the environment, but also recover useful resources and achieve sustainable development.

3. SELECTION OF SLAG MUD WATER SEPARATION EQUIPMENTC

3.1. Composition and characteristics of slag mud water

During the construction of underground tunnels, the shield machine will produce a large amount of muck slurry, which is mainly composed of the following parts:①Original rock and soil mass: This is the main component of mud water, including sand, gravel, clay and other particles of different particle sizes.②Water: used for cutting and cooling of the shield machine, as well as maintaining the stability and fluidity of the soil.③Additives: In order to improve the performance of the slurry, some chemical additives, such as bentonite, polymer, etc., may be added to increase the viscosity and stability of the slurry.④Cutting rock and soil debris: These are produced during the cutting process of the shield machine cutter.⑤Metal wear debris: Some metal wear debris may be generated during the cutting process of the shield machine cutter head and tool.

Mud-water characteristics of muck:①Suspension: The solid particles in the slurry can be uniformly suspended in the liquid to form a stable suspension.②Viscosity: The viscosity of the slurry directly affects its fluidity in the pipeline and its ability to carry the muck.③Stability: The stability of slurry refers to its ability to maintain a suspended state and is not easy to stratify or precipitate.④The pH value: The pH value of the slurry may vary due to different geological conditions and additives, and usually needs to be controlled within a certain range to ensure construction safety and environmental protection.⑤Solid content: The solid content of slurry refers to the mass of solid particles in unit volume of slurry, which is an important parameter to measure the performance of slurry.⑥Filtration: The filterability of slurry refers to its ability to pass through the filter medium, which affects the formation of filter cake and dehydration effect.⑦Specific gravity: The proportion of mud water is usually greater than that of water, which helps it carry muck in the shield machine. ⑧ Chemical composition: The chemical composition of the mud may contain a variety of ions and compounds, which may come from geological materials or additives.⑨Temperature: The temperature of the slurry may vary due to geological conditions, additives and the working state of the shield machine.

3.2. Design of slag-soil-slurry separation system

In order to solve the above problem of shield muck disposal and achieve the purpose of construction waste reduction, it is planned to introduce shield muck slurry separation station. According to the actual situation that the particle size of shield muck is relatively small, but the water content is too high or in the flow plastic state, several muck slurry separation methods can be used, as shown in Table 1.

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Table 1. Comparison of several mud separation methods

Order	Name	Principle	Scope of application	Advantages	Defect
1	Gravitational sedimentation	The gravity sedimentation method uses gravity to make the solid particles in the slurry mixture settle to the bottom of the container under the action of gravity.	It is mainly used to deal with mud-water mixture with large particles and fast settling velocity, such as coarse-grained slag soil produced by tunnel excavation.	The equipment is simple, easy to operate, low operating cost.	For small particles and suspended solids, the effect is poor, the sedimentation rate is slow, and the area is large.
2	centrifugal separation	Using the action of centrifugal force, the mud-water mixture rotates rapidly, and the solid particles are thrown to the container wall under the action of centrifugal force, so as to realize solid-liquid separation.	Suitable for all kinds of particle size of slurry mixture, especially small particles.	The separation efficiency is high and the area is small.	The equipment has high cost, large energy consumption and complex maintenance.
3	Chemical flocculation precipitation method	By adding chemical agents, the fine particles in the mud-water mixture are aggregated into larger particles, thereby accelerating sedimentation or facilitating filtration.	It is suitable for the treatment of mud-water mixture containing a large number of fine suspended solids and colloidal particles.	The separation efficiency is high and the processing speed is fast.	It is necessary to use chemical agents, which may cause secondary pollution to the environment and high operating costs.
4	Pressure filtration separation method	Using the pressure of the filter press, the water in the slurry mixture is squeezed out, so as to achieve solid-liquid separation.	It is suitable for treating various mud-water mixtures, especially the mud-water containing a large amount of suspended solids.	The separation effect is good and the water content is low.	The cost of equipment is high, and it needs to occupy a large area of site.
5	Belt pressure filtration separation method	The separation of solid and liquid in mud is realized by the extrusion and filtration of filter belt.	It is suitable for the slurry with certain fluidity, not suitable for the more viscous slurry.	Large processing capacity, high degree of automation, easy maintenance	The initial investment is high, the area is large, and the filter belt is easy to deviate.
6	Filter separation method	The solid particles in the slurry mixture are trapped on the surface of the filter medium by setting a filter screen or filter cloth to achieve solid-liquid separation.	It is suitable for mud-water mixture containing more fine particles.	The separation effect is good, and the fine particles can be treated.	The filter or filter cloth is easy to be blocked and needs to be replaced or cleaned regularly.
7	Deep cone mud separation method	Solid-liquid separation technology based on the principle of gravity sedimentation and concentration.	It is suitable for treating high concentration suspension.	It has strong processing capacity, high efficiency, small footprint and simple operation.	The initial investment is large, the maintenance cost is high, and the requirements for mud properties are high.
8	Vacuum dehydration	By using the negative pressure generated by the vacuum pump, the water in the slurry mixture is extracted, so as to realize the solid-liquid separation.	It is suitable for treating mud-water mixture with high water content.	The dehydration effect is remarkable, which can significantly reduce the volume of mud water.	The equipment is complex, the energy consumption is high, and the operation technical requirements are high.

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The treatment of sludge water discharged from shield machine is a complex process, and it is necessary to select the appropriate treatment method according to its composition and characteristics, so as to realize the effective utilization of resources and environmental protection. Therefore, it is more appropriate to choose the treatment technology combining pressure filtration separation and flocculation precipitation based on the comparison of the effect, application scope and advantages and disadvantages of slag slurry separation.

The size of the shield interval muck slurry separation station is 31.5m (length) × 15m (width). The shield muck slurry separation and treatment system consists of feeding, screening, raw material pile, sewage treatment system, power supply system and corresponding auxiliary facilities. The filter press consists of a frame, a filter plate, a pressing system (manual, mechanical, hydraulic) and an electrical control cabinet. The frame part plays the role of supporting the pressing device and the filter plate, which is composed of the frame, pressing plate, thrust plate and main beam. The filter plate is installed on the main beam between the pressing plate and the thrust plate, and the filter cloth is clamped between them. When working, the pressing device (cylinder piston rod or screw) pushes the pressing plate, presses the filter plate and filter cloth between the pressing plate and the thrust plate, and forms a filter chamber between the pressed filter plate and the filter plate. The material pressed by the material pump enters each filter chamber from the feed hole of the thrust plate. The solid particles are retained in the filter chamber and form a filter cake. The liquid is discharged from the outlet hole through the filter cake and filter cloth. If the filter cake needs to be washed, the washing water can be introduced into the washing port on the tail plate to wash the filter cake. If the filter cake needs to be dried, the compressed air can be introduced into the washing port to dry the filter cake. The structure of the frame filter press frame is the same as that of the box filter press, except that the filtration part is composed of a plate, a frame and a filter cloth, and the frame space is the filter chamber. The flow form of the filter press is divided into open flow and dark flow. The open flow refers to the filtrate discharged directly from the outlet hole of each filter plate. Underflow refers to the filtrate of each filter plate is combined and discharged from the outlet channel.

Before the installation of the muck slurry separation system, the equipment can be installed after a simple transformation of the site. The original shield site construction access road layout is smooth and the drainage is good, which can meet the site needs of the muck treatment equipment.

3.3. Technical parameters of slurry separation equipment

According to the characteristics of sandy mudstone in the tunnel and the reference value of the comprehensive gradation of muck slurry in this project, in order to meet the requirements of shield tunneling progress, the overall design is mature, applicable, reliable, reasonable and adjustable to ensure the normal operation of the muck slurry disposal system. The equipment parameters of the muck slurry treatment system are selected as shown in table 2.

3.4. The working process of slurry separation equipment

The steps of shield muck slurry separation equipment work

(1) Residue screening

Two excavator walkways are installed on the large mileage side of the muck pit near the interval. An excavator is equipped to load the muck in the muck pit into the separation sieve for screening. The screening machine is installed on the side of the muck pit near the muck mud water separation station. The stones with a particle size greater than 5mm and the mud water with a particle size less than 5mm are separated. The stones and particles with a particle size greater than 5mm are stored and transported by truck. The particles and mud water with a particle size less than 5mm are stored in the sewage pool on the side of the screening machine.

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A 55Kw sewage lifting pump is set in the sewage pool to pump the mud water into the flocculation tank for mud water separation treatment.

Table 2. Slag soil treatment system equipment parameter table

Order	Equipment name	Equipment composition	Equipment variables	Equipment pictures
1	High pressure filter press	Electric control system Feeding system Drainage system Hydraulic system	Equipment Model: KXMZ500 / 1500 Discharge standard: surface water class II standard Overall performance: meet the shield muck slurry disposal Number of equipment: 2 Treatment requirements: meet the national rainwater pipe network discharge standards	
2	Separating sieve	Host Vibration motor Damping spring	Equipment Model: 2460 Motor power: 22KW * 2 Processing capacity: 60-110t / h Number of equipment: 1 Equipment use: primary screening, dehydration	
3	filter press feed pump	Motor Impeller Bearings Feeding room	Equipment Model: 100ZJE-460 Motor power: 55kw Processing capacity: 240-300 m 3 / h Number of equipment: 2 Equipment use: filter press feeding	
4	sewage lift pump	Motor Impeller Bearings Feeding room	Equipment model: 10 cubic mixing tank Equipment Model: 150HYZD-350 Motor power: 75kw Processing capacity: 300-450 m 3 / h Number of equipment: 1 Equipment use: sewage lifting	
5	control cabinet	Soft start Electric cabinet box Voltage ammeter Control button	Number of equipment: 5 Equipment use: secondary electric cabinet and feed pump control	
6	PAM flocculation system	Reducer Motor Bearings Mixing rod	Equipment Model: 10 Cubic Mixing Tank Motor power: 15KW Processing capacity: 10m 3 / h Number of equipment: 1 Equipment use: mud water dosing separation	

(2) Mud water flocculation treatment

The flocculation tank is used to separate the mud and water, and the treated water is formed to meet the requirements (up to the national secondary emission standard) and transported to the clear water tank through the pipeline, which can be used for washing vehicles and other recycling. The separated slag and mud are transported to the filter press through two 55 Kw slurry pumps for further treatment.

(3) Pressure filtration treatment

Two 55 KW slurry pumps were set up at the bottom of the flocculation tank. The separated slag and mud were transported to a 500 square filter press for secondary slurry separation. The water was separated to a clear water tank, and the dried mud cake was stored and waited for treatment.

(4) Filter cake treatment

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If the filter cake needs to be washed, the washing water can be introduced into the washing port on the tail plate to wash the filter cake. If the filter cake needs to be dried, the compressed air can be introduced into the washing port to dry the filter cake. Finally, it can be stacked in the storage area, waiting for loading and shipping.

The process flow of the shield slurry treatment system is shown in Figure 1.

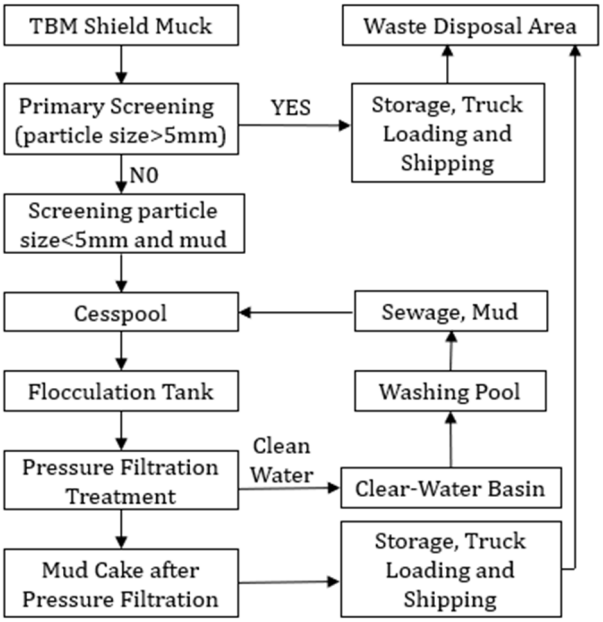

Figure 1. Process flow diagram of slurry treatment system

4. PRACTICAL APPLICATION OF ENGINEERING CASE

4.1. Engineering situations

The starting and ending mileage of the right line of the two-station section of Chongqing Rail Transit Line 18 is YDK0+194.256~YDK0+843.729, with a length of 649.473m, of which the shield section is 619.473 m; the starting and ending mileage of the left line is ZDK0+194.256 ~ZDK0+843.729, the long chain is 16.875m, the length is 666.348m, and the length of the shield section is 590.223m. The structure is a circular section, the minimum turning radius is 360 m, the maximum slope is 39‰, and the buried depth is 42.3 m~81.65m. At both ends of the interval, a 15m subsurface excavation section (left line A section 46.125m) is set up, and a horseshoe-shaped composite lining structure is set up. A contact channel is set up in the middle of the interval. The plane diagram of the two stations is shown in Figure 2.

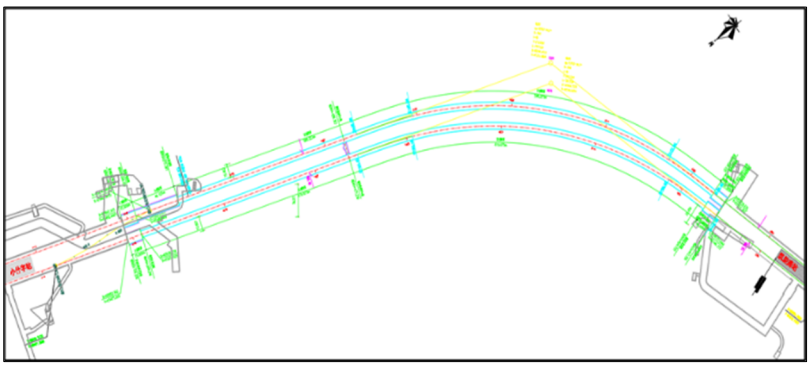

Figure 2. Two-station interval plane diagram

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(1) Geological Structure

The occurrence of the rock layer is 89°~120°∠4~10°, and the dominant occurrence is 120°∠4°. There are two groups of structural fissures: J1: 270~300∠54~77, extending 5~10m, slightly stretching 1~3mm, straight, spacing 1.0~2.0m, occasionally muddy filling, poor combination, belonging to weak structural plane ; j2: 190~220∠67~84, extending 1~5m, generally closed to slightly open, soothing wavy, local flip phenomenon, spacing of 5~8m, occasionally muddy filling, poor bonding, belongs to the hard structural plane.

The sandy mudstone is mainly purplish red. The main mineral components are clay minerals, silty argillaceous structure, medium-thick layered structure. The cracks of moderately weathered rock mass are not developed. The rock mass is relatively complete and the rock is hard. The saturated compressive strength is between 4.00 and 12.00 MPa, and the standard value of saturated compressive strength of rock mass is 7.20 MPa. Combined with the actual situation of the whole layer of the site, it is comprehensively judged to be extremely soft rock, and the basic quality grade of the rock mass is grade IV. The sandstone is generally gray-brown gray, fine-medium grained structure, thick layered structure; the main mineral components are quartz and feldspar, containing a small amount of mica and clay minerals. Most of them are calcareous cementation, and some are argillaceous cementation. The rock is hard and the rock mass is relatively complete. The saturated compressive strength is between 24.30 MPa and 35.00 MPa, and the standard value of saturated compressive strength of rock mass is 26.20 MPa. The proposed engineering geological conditions are mainly sandstone and sandy mudstone, which appear in an interbedded state. The rock mass is moderately weathered, the joint fissures are not developed to relatively developed, the rock mass is relatively complete, and the overall geological conditions are good. The geological section of the two stations is shown in Figure 3.

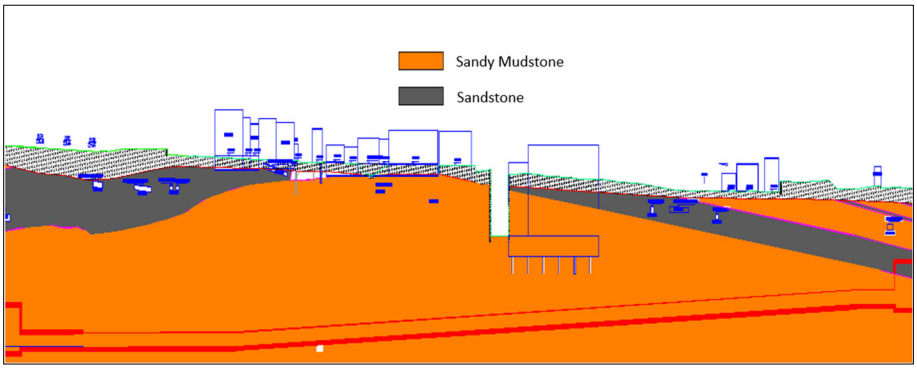

Figure 3. Geological section map of the two stations

(2) Hydrology Situation

The exploration area is located on the structural denudation hilly landform, and the thickness of the Quaternary overburden varies greatly, among which the thickness of the overburden in the gully area is generally larger. The bedrock is a continental clastic rock interbedded with sandstone and mudstone, with weak water content. The water abundance of groundwater is controlled by topography, lithology and fracture development, which is mainly recharged by atmospheric precipitation and urban underground drainage pipeline leakage. According to the occurrence conditions, hydraulic properties and hydraulic characteristics of groundwater along the line, the complexity of the hydrogeological conditions of the site is medium complex, and the groundwater along the line can be divided into Quaternary loose layer pore water and bedrock fissure water.

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The surface of the field area is poorly sealed. The groundwater in the exposed strata is mainly recharged by the infiltration of atmospheric precipitation. The shallow strata become the groundwater recharge channel. A part of the atmospheric precipitation is discharged along the slope, and a part of it sneaks into the underground along the weathered cracks, and then flows out of the surface in the form of spring wells from the low-lying terrain. The groundwater recharge and discharge conditions in the field area are good, and the groundwater flow is strictly controlled by atmospheric precipitation. The water in the rainy season is large, and the water in the dry season is small or cut off. The groundwater in the field area has the characteristics of single recharge condition, short-distance runoff and nearby discharge. The structural fractures in the rock strata are generally not developed to relatively developed, which is conducive to the occurrence and acceptance of groundwater. The groundwater in the site is mainly distributed in the residual slope of the low-lying land and the pores of the artificial filling soil layer. The water level changes greatly and there is no stable groundwater level.

4.2. Application of mud water separation equipment

(1) Requirements of Slurry Separation Equipment

The production capacity of the slag treatment system is 500 m^3/day. The shield muck is lifted from the slag hopper to the feeding machine above the slag pool at a speed of 80-120 m^3/h, and transported to the pre-screening treatment. The $\geqslant$5mm large particles are screened to the solid silo, and the <5mm particles and mud water enter the sewage pool below the screening. The sewage pool uses a 55KW sewage lifting pump to raise the sewage to a 300m^3 concentration tank for treatment. Two 55Kw slurry pumps are transported to two 500m^3 filter presses for mud-water separation, and the clean water is separated to the clear water tank. After the pressure is dried, the mud cake is waiting for loading treatment. Finally, the moisture content of the mud cake after the filter press is less than 30%.

According to the results of the total processing capacity of the system and the calculation of the process flow, the processing capacity of each workshop is calculated. The treatment capacity of muck is 50m^3 per hour, the treatment capacity of slurry is 75m^3 per hour, and the treatment capacity of filter press is 30m^3 per hour.

(2) Equipment Use

Close the power switch, the power indicator light is on ; Start the oil pump (while checking whether the oil pump is working properly); moving all the filter plates to the end of the thrust plate and placing them in the middle of the two beams; Start the pressing button, the piston pushes the pressing plate, presses all the filter plates, holds the pressure after reaching the pressure value, presses the closing button, and the oil pump stops working; Underflow: open the filtrate valve to discharge the liquid. Open flow: open the nozzle to discharge liquid. At the same time, open the feed valve for filtration ; After the feeding is completed, the feeding valve is closed and the filtration is stopped; washable type: open the nozzle, then open the washing water valve, water washing; start the oil pump, press the pressing button, lock the nut, the nut will be screwed to the front end of the piston rod (pressing plate end), and then press the release button, the piston pressing pull back to the appropriate working gap, close the motor; mobile pull plate for unloading ; check the filter cloth and filter plate, and clean up the residue on the bonding surface. If there is no problem, you can enter the next work cycle.

(3) Notice

Clean the filter cloth according to the regulations, increase the water permeability of the filter cloth, and improve the pressure filtration efficiency. Stop feeding before shutdown, and remove all materials in the filter press before shutdown. After loosening the frame, the residue must be removed from the plate and then removed with a small plastic wedge. When cleaning the frame and filter cloth, the channel should be smooth, and the soil slag should not be adhered to the

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202410_10(10).0006

sealing surface or fed on the channel. When the installation plate moves on the main beam, the plate frame shall not collide or fall, and the force shall be applied evenly to avoid damage to the handle and sealing surface. The removed frame should be flattened to prevent deformation. The sealing surface of the filter plate must be clean and wrinkle-free. The main beam of the filter plate should be vertical and neat, and there must be no deviation. The filter cloth should avoid entrainment and folding, the surface of the filter plate should be smooth, and the handle of the filter plate should be gently held. During compression, the filter must not deviate from the center line.

4.3. Separation effect of slag mud water

Through the use of the above selection method for shield muck slurry separation operation, after the on-site slurry separation effect evaluation, the filter press mud cake moisture content can achieve the effect of less than 30%. The effect diagram of the soil pressure filtration treatment of the shield slag is shown in Figure 4.

Figure 4. Effect diagram of shield muck after pressure filtration treatment

5. CONCLUSION

Based on the background of Chongqing subway shield tunnel project, the characteristics of tunnel shield muck slurry are analyzed by summarizing the muck slurry separation technology, and then the slurry separation equipment suitable for the project is designed. The main conclusions are as follows:

(1) The residual soil is first screened for particle size through mechanical feeding, followed by flocculation and precipitation, and then filtered into a mud cake. Finally, it is washed and dried as needed and transported for disposal.

(2) The treatment capacity is strong, can be operated continuously or intermittently, the solid content of the filter cake is high, and the dehydration effect is good. It has strong adaptability to mud and can handle mud with different particle size distribution.

(3) The moisture content of filter cake can reach less than 30 %, which is a relatively ideal result.

In the later stage, relevant research on slurry recycling after slurry treatment of shield muck can be carried out, which will save more construction materials, be economical and environmentally friendly. Although there have been similar cases in engineering, not all projects can be fully adopted.

ACKNOWLEDGEMENTS

This paper has been supported by the project entrusted by the Fourth Engineering Co., Ltd., China Communications Second Public Bureau.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202410_10(10).0006

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