

Practice Study on Grouting Treatment Engineering of Broken Rock Mass

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Abstract: The fractured rock mass is the unfavorable geology often exposed during the construction of the subway. Combined with the problem of seepage water in the side wall of the Xiangjiang Road station of Qingdao Metro, it explores effective means to control the fractured rock mass. Through the engineering hydrogeology and the surrounding environment analysis of the foundation pit, the ground curtain grouting scheme of the whole station is adopted to block the groundwater outside the pit of the station. The grouting borehole design, grouting parameter design, grouting dynamic monitoring control, etc. are determined in turn, wherein the grouting material adopts 800 mesh ultra-fine cement, fully considering the crack opening problem. The grouting method adopts forward section grouting, which fully considers the problem of poor integrity of fractured rock mass. Finally, the effectiveness of the grouting method is verified by engineering test section. The research results show that the super-fine cement ground surface curtain grouting method can better solve the problem of seepage water in fractured rock, and can provide reference for similar projects.

1. Introduction

Since the 21st century, urban rail transit has entered a golden age of development. It is not uncommon for more urban subways to expose bad geology during the construction process. The fractured rock mass is characterized by its small integrity, low strength and the development of fractures, resulting in frequent leakage of water. Due to its small integrity, low strength and development of fractures, the fractured rock mass causes frequent leakage of water, which seriously affects the construction process and causes huge economic losses.

As an effective means of sealing groundwater, grouting technology is widely used in the grouting process of fractured rock mass. The slurry penetrates into the fissure channel, envelops the fractured rock mass, improves the integrity and strength of the fractured rock mass, and acts to seal the groundwater, thereby meeting the construction requirements and the treatment of the leakage of the fractured rock mass during the operation period. However, due to insufficient slurry penetration, low effective retention rate, and incomplete treatment, many projects are unable to completely block the seepage channel, resulting in failure to meet the acceptance criteria during the construction period and normal operation during the operation period.

At present, relevant research is not comprehensive. For example, Du et al. modified the ordinary cement slurry with the addition of external admixture to adjust the cement hydration and hardening process, and formed the SJP viscosity time-varying grouting material. The viscosity of this material during the process of strengthening the fractured rock mass was studied. (Du et al.20). Zhao et al used grouting to simulate the fractured rock strata in the goaf and carried out grouting test to determine the diffusion distance, the proportion and concentration of the grouting material, the grouting control pressure, the grouting filling rate and the stone body strength. Provided the basis. (Zhao et al.20).



Zhang et al. comprehensive grouting analysis of gushing water in limestone breccia fracture zone. (Zhang et al.20).Zhang et al. carried out the multi-stage grouting test of the water-rich broken rock mass by using the self-developed three-dimensional grouting model test system, and obtained the multi-physics evolution law of the rock mass under grouting disturbance.(Zhang et al.20). Li et al. carried out grouting reinforcement for water-rich broken rock mass by ordinary silicate cement 42.5# (PO.42.5), sulphoaluminate water 42.5# (SAC.42.5) and self-developed cement-based composite grouting material (CGM) Effect experiment. (Li et al.20). Wu et al. carried out the experimental study on the shallow grouting method of chemical grouting in weak broken ore bodies. The chemical grouting method of cracks was determined by comparison, theoretical calculation and analogy analysis of different grouting methods. (Wu et al.20). Li et al. carried out the secondary grouting reinforcement test of the large loose zone surrounding rock in Zhaozhuang Coal Mine. The test results show that the secondary grouting reinforcement effectively improves the overall strength of the surrounding rock.(Li et al.20).

In summary, the current research is mainly focused on the fracture rock mass and fault fracture zone test. Although a small number of studies are involved, most of them focus on the study of chemical grouting materials, while chemical grouting materials are in the city. For the construction of the subway, the applicability is lower. In addition, current research lacks methodological innovation. In response to this situation, relying on the excavation of the Xiangjiang Road Station of Qingdao Metro to expose the problem of broken rock mass, a systematic method for curtain grouting and water blocking at the whole station is proposed. The method forms the curtain grouting method for the surface of the whole station from the difficult point analysis of engineering hydrogeological conditions, grouting drilling design, grouting parameter design and grouting method design. Through practice verification, the method is more feasible and has better governance effect, which can better solve the difficult problem of the fractured rock that is currently faced.

2. Project Overview

Xiangjiang Road Station is located on the south side of Jinggangshan Road and Xiangjiang Road Cross. Laying along Jinggangshan Road. The east side of the station is Maju Canal Park, and the west side is Qianzhi Square, Zijin Square, Baodao Club, etc. The northwest side is Qingdao Customs, and the northeast side is Ginza Jiayu Hotel. The red line of Jinggangshan Road is 30m wide, with two lanes and four lanes. The red line of Xiangjiang Road is 15m wide and has two lanes of four lanes. The station is a two-story island-type standard station with single-column and double-span (local double-column and three-span) box-type structure with a structure width of 19.7m, a platform width of 11.0m, and an average roof covering thickness of 4.0m. The station is divided into two phases: the main structure of the first-stage construction station, and the auxiliary parts on both sides of the second-stage construction station. Both ends of the station are mine law intervals. The length of the main foundation pit is 173.0m, the standard section width is 19.7m, and the depth is 17.8m~18.7m. During the main body of the construction station, two-way four-lane roads are set on the east side of the first-stage enclosure to meet the requirements of borrowing one by one, which can ensure the smooth operation of Jinggangshan Road during construction.



Figure 1. Left and right line geological longitudinal section

3. Analysis of Difficulties in Engineering Management

The key points and difficulties of grouting reinforcement in the test section of the fractured rock mass in this section are mainly the following three aspects:

(1) Geological specificity

The target area of the foundation pit treatment of this station is fractured rock. After long-term weathering, the fractured rock develops, the surrounding rock is inferior in integrity, and the fissure water is rich, so there is a high requirement for grouting effect. Otherwise, local fragmentation of rock mass collapse and lining deformation will invade the pit boundary, which will affect the stability of foundation pit support and threaten the safety of foundation pit.

(2) Intensive buildings around

There are many buildings around the station, and the main buildings are Qianzhi Square and Zijin Square. The basement of Zijin Square is 5m away from the main foundation pit. The surface uplift is very sensitive, and may be accompanied by slurry running and invading the basement, which seriously increases the difficulty of grouting. As shown in the following table.

Table 1. Relationship between adjacent buildings and station pits

Serial number	Building and structure name	Structure form and number of layers	Distance from the main foundation pit
1	Zijin Square	Frame shear structure、33F, Box foundation、-2F	5m from the basement
2	Qianzhi Square	Frame cylinder structure、24F, Box foundation、-2F	Minimum distance 46.5m
3	Baodao Club	Frame structure、2F, Independent foundation	Minimum distance 29.5m

(3) Deformation of the side wall and surrounding pipeline of the foundation pit

The main pipelines in the foundation pit are open channels (The Mahao Canal is about 11m wide and 1~3m deep. It is about 20m away from the main pit of the station.), cast iron pressure pipes (DN1000), sewage pipes (DN1000), other sewage pipes (DN400), rainwater pipes (DN400) and some communication lines. Before the excavation of the foundation pit, the pipeline within the foundation pit has been moved to the outside of the foundation pit. Deep excavation of the foundation pit may cause instability of the surface fill layer or flow soil and sand, causing deformation of the foundation pit and subsidence of the ground; and the impact of the blast on the underground pipeline.

During the grouting process, it is necessary to strictly control the deformation of the side wall of the foundation pit and the cracking caused by the grouting diffusion. Prevent the occurrence of safety accidents on the side wall of the foundation pit. The open excavation station is located in a bustling area, and it is necessary to strictly control surface bulging and deformation of surrounding pipelines.

4. Design of grouting scheme

4.1. Grouting drilling arrangement

In order to consolidate the Xiangjiang Road Station of the two phase of the red island-Jiaonan intercity rail transit project. In order to ensure the stability of the excavation, the surface grouting scheme is adopted around the foundation pit through the pre grouting in the test section. The general layout plan of the drill hole and the sample section of the test section are shown as follows.

The surface grouting scheme for foundation pit is designed with 1 rows of 155 grouting holes. There are 68 holes on the east side, 68 holes on the west side, 10 holes on the south side, and 9 holes

on the north side. Drilling at the vertical center of the jet grouting pile, the depth of drilling is 20m, the spacing is 2.5m, the length of the orifice pipe is 8m, and the 2m pressure expansion die bag [8] is used. The progressive subsection grouting method is adopted. The first grouting area is 8-14m and the second grouting zone is 14-20m.

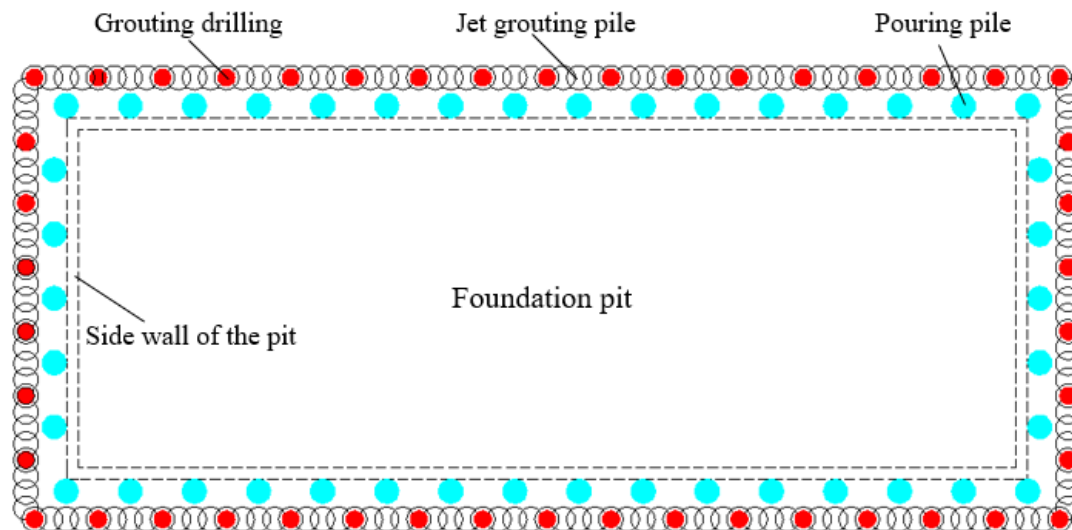


Figure2. Plane sketch map of grouting drilling

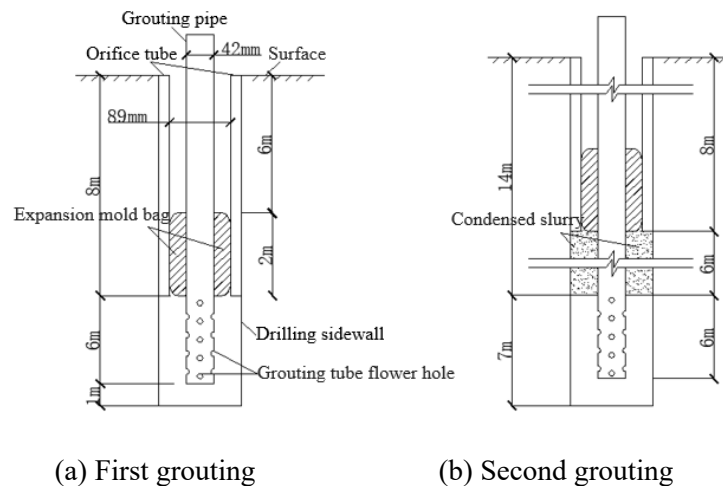


Figure3. Sketch map of the longitudinal section of the grouting hole

4.2. Design of grouting parameters

(1) Serous type

For the fractured rock mass, the grouting material mainly adopts 800 mesh superfine cement, the water cement ratio is 1.5:1, the cement-water glass double liquid is used to control the grouting diffusion and the side wall of the foundation pit, the volume ratio of cement and water glass is 1:1~3:1, the cement slurry is the ordinary 42.5 cement slurry, and the concentration of water glass is between 35-42°Bé.

(2) Grouting pressure

The final pressure of superfine cement single liquid grouting is controlled at 1.5~2MPa. If there is too much grouting or single hole grouting, a small amount of double slurry is injected for plugging channel.

(3) End standard of grouting

The single hole grouting pressure reaches the final pressure of the design and continues to grouting more than 10min. It can end the grouting of this hole. The single hole grouting amount is approximately the same as the design grouting amount, and the grouting amount below 20-30L/min can end the grouting.

4.3. Monitoring of grouting

According to the previous geophysical exploration and drilling situation, a monitoring site was set up in the foundation pit management area for dynamic monitoring of grouting and excavation, including:

(1) Real-time monitoring and early warning of ground deformation during grouting

In the process of grouting, the DSZ-3 Level is used to monitor the surface uplift of the grouting area in real time. Control single hole grouting so that the amount of uplift is not too large, The process of grouting leads to the amount of ground uplift is not exceeding the specified value, so as to ensure the safety of road surface, building and pipeline in the process of grouting.

(2) Real-time monitoring and warning of foundation pit deformation during grouting

In the process of grouting, real-time monitoring and early warning of foundation pit deformation should monitor the stability of the foundation pit side of grouting treatment section.

(3) On-line monitoring of grouting parameters

The grouting pressure and flow are monitored respectively in the grouting process. According to the monitoring of the grouting pressure and flow rate of the grouting orifice, the construction personnel ensure that the grouting pressure is not too large, the grouting amount reaches the design value, and the grouting diffusion range is strictly controlled according to the design scheme to ensure the grouting effect.

5. Field grouting

Figure 4 shows the procedures of whole grouting. In order to ensure the integrity of the reinforcement area, subsection split grouting technology was used. Subsection split grouting technology could make grouting from shallow to deep and push layer by layer.

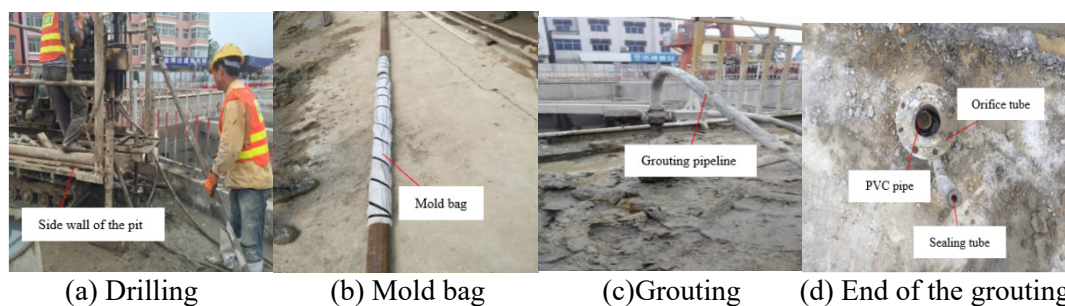


Figure 4. The procedures of whole grouting

Figure 5 shows the situation of field sidewall after grouting. After grouting, the leakage area of the side wall was observed to disappear. For the excavation area which was excavated before grouting, there was not serious leakage area of the side wall.

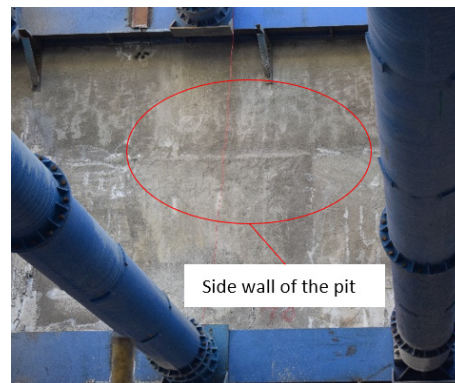


Figure5. The situation of field sidewall after grouting

6. Conclusions

(1) Based on the original engineering geological data, the detailed investigation of field and surrounding conditions of Xiangjiang Road Station, the difficulties in the treatment of fractured rock mass, treatment area, effect and cost were analyzed, therefore, the whole station surface curtain grouting water plugging method was formed.

(2) Considering the characteristics of fracture development and small opening of fractured rock mass, ultrafine cement was chosen as grouting material to satisfy the effect that the slurry can fill the whole fissure space and achieve the effect of radical cure.

(3) The design of grouting hole, grouting parameters, grouting method were determined in turn. The rationality of the grouting scheme was verified by the engineering practice. The results showed that the scheme had a good effect on the leakage of fractured rock mass and could be used for reference in similar projects.

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