

# *Study on Grouting Reinforcement Method under Soft Water-rich Sand Layer in Metro Station*

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**Abstract:** The Quaternary water-rich sand layer, which is often traversed during the construction of subway tunnels, is one of the main geological disaster sources that affect the safety of subway construction. The formation is rich in water, low in bonding strength, and has poor self-stability. It is very easy to induce engineering disaster accidents such as tunnel collapse, water gushing and sand collapse. Grouting method is the most commonly used method to control geological hazards of water-rich sand layer. Grouting can effectively enhance the cohesion of the sand layer and enhance the compressive strength of the sand layer. This article mainly aims at the subway station passing through the sand layer, adopts the advanced curtain grouting method, and cooperates with the specific grouting technology to grouting the sand layer within 12m in front of the tunnel to ensure the stability and safety of tunnel excavation.

## 1. Introduction

At present, China has entered a period of large-scale subway construction. However, during the construction of subway tunnels, they often traverse the Quaternary water-rich sand layer. Due to the low bond strength and poor self-stability of the medium, it is very easy to induce engineering disasters such as tunnel collapse and water collapse due to engineering disturbances and groundwater. Leading to casualties, economic losses and delays in construction period, and even forced to stop construction. Such as: Under construction of the Qingdao Metro Line 2 beer ~ Miao section tunnel, the tunnel under the city's main road, buried depth of 11 ~ 16m, during the excavation process exposed the Quaternary water-rich sand layer, due to sufficient groundwater recharge, the formation is stable The property is extremely poor, leading to multiple sand collapse failures in the cave. Afterwards, the sand collapse collapsed into the ground and formed ground collapse, which seriously threatened the safety of the surface pipelines and surrounding buildings. The construction period was delayed for more than 1 year.

Water-rich sand layer disaster prevention and control is a dynamic process, and grouting process control [1-4] is the key to ensure the effect of grouting treatment. In the research of grouting control

of water-rich sand layer disasters, controlling the grouting process can control the slurry within the scope of treatment and control the slurry to meet the grouting requirements. Traditional grouting control methods [5-7] mainly include quantitative control method and constant pressure control method, that is, the grouting volume and grouting pressure are used as the judging criteria for the grouting end. When the grouting amount or grouting pressure reaches the design value At that time, it is considered that effective reinforcement has been achieved and the grouting is completed.

This article takes the subway crossing the water-rich sand layer as the research background, and uses the advanced curtain grouting method to grouting and reinforce the sand layer within 12m of the tunnel face, which has achieved good governance effects and ensured the smooth excavation of the tunnel. , Provide a certain reference value for similar grouting reinforcement projects.

## 2. Engineering background

The tunnel is excavated by the mining method. The excavation section width is 6.5m and the section height is 6.9m. The up and down steps method is used for construction.

The buried depth of the tunnel is 13 ~ 15m. The strata exposed on the upper and lower sections of the tunnel are dominated by strongly weathered strata. There is a bedrock layer with a thickness of about 4 meters above the vault of the tunnel. The bedrock is a strongly weathered rock stratum. The bedrock is 2-5m thick and viscous. Coarse gravel sand as shown in Fig.1.

Above the tunnel is the current Liaoyang Road. There are many municipal pipelines in the area affected by tunnel excavation and grouting, such as water supply, rainwater, sewage, communications, and power. The pipeline depth is 1 ~ 4m.

### (1) High control requirements for grouting process

The grouting treatment strata in this section are mainly water-rich and weathered rock masses with abundant groundwater and well-developed joint fractures. The slurry is prone to disorderly diffuse along the dominant fracture channels. High control accuracy is required.

### (2) The effect of grouting reinforcement is high

The thickness of the cover rock of the tunnel in this section is small, and the water-rich sand layer above the cover rock. There is a risk of sand collapse and collapse during tunnel excavation, which requires higher grouting reinforcement effect.

### (3) Surface uplift and pipeline deformation

There are municipal pipelines such as water supply and rainwater above the tunnel. During the grouting process, it is necessary to strictly control the surface uplift and pipeline deformation to ensure the safety of the pipeline during the grouting process.

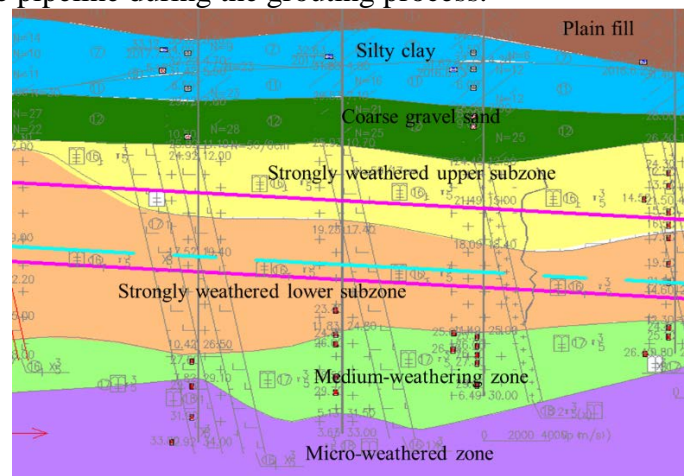


Figure. 1 Tunnel surrounding rock geological section Difficulties in the reinforcement project

### 3. Grouting reinforcement method

#### 3.1 Grouting reinforcement range

The advance grouting range of the tunnel is the upper half of the tunnel, the thickness of the grouting reinforcement ring is initially determined to be 5m, the length of each grouting reinforcement is 12m, the excavation length is 9m, and 3m grouting and solids are reserved for the next grouting cycle Rock slurry plate.

#### 3.2 Drilling layout

For all grouting holes, the grouting construction is carried out by using the staged grouting technology, and the length of the stage is 3-5m. The grouting hole layout is shown in Figure 2 ~ 6.

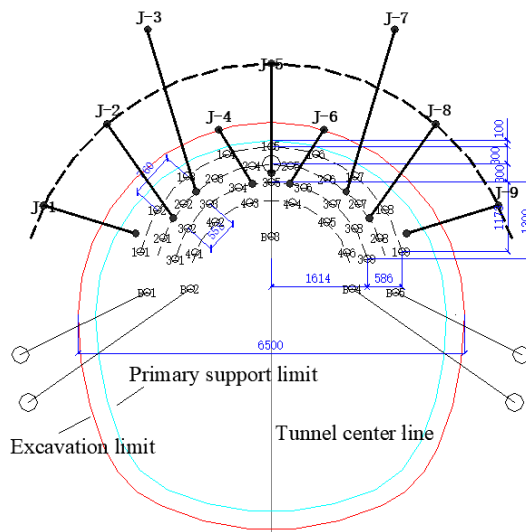


Figure. 2 Drilling hole location diagram (unit: mm)

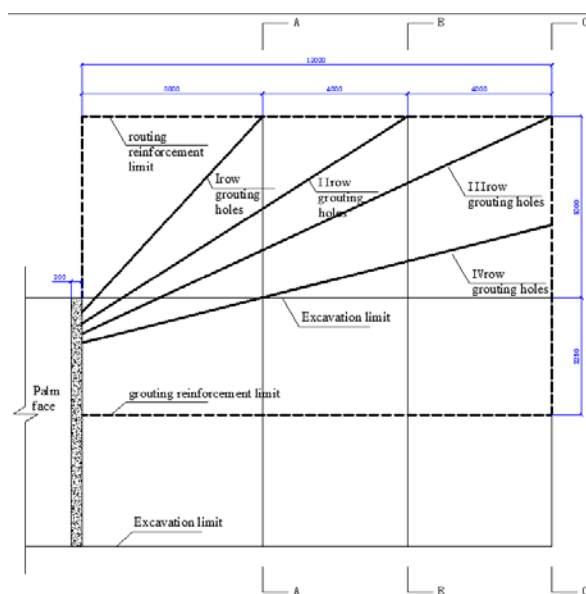


Figure. 3 Longitudinal section drawing of grouting reinforcement range (unit :mm)

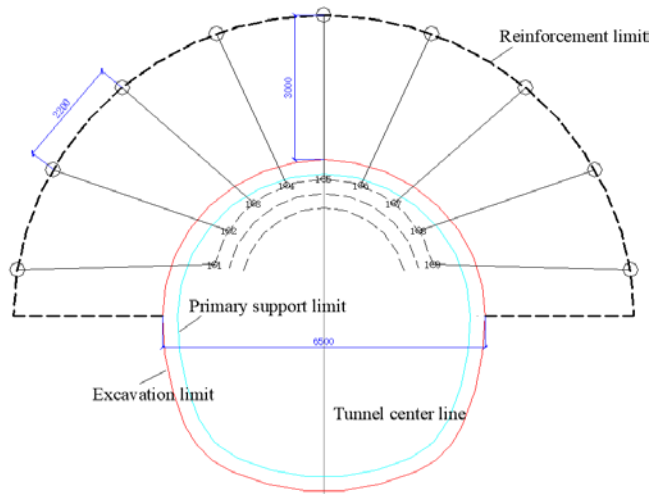


Figure. 4 Plan view of the position of the final hole in section A (unit :mm)

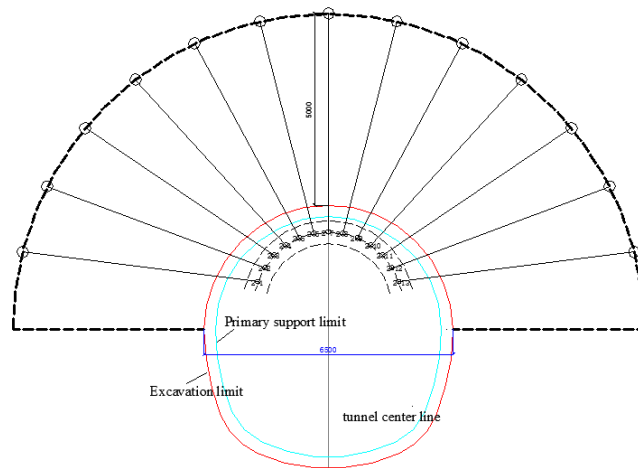


Figure. 5 Plan view of the position of the final hole in section B (unit :mm)

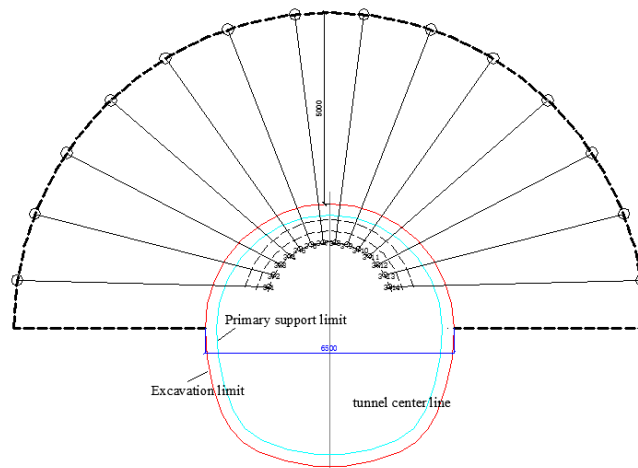


Figure. 6 Plan view of the position of the final hole in section C

## 4. Grouting parameter design

### 4.1 Grouting material

The grouting material adopts single cement slurry + cement-water glass double slurry, comprehensively utilizes the advantages of good long-term stability of single cement slurry and controllable diffusion range of cement-water glass dual slurry, to achieve high efficiency of strong weathered fractured rock Reinforce water plugging.

①Single-liquid cement slurry: cement model P.O42.5, its ratio is W: C = 1: 1.

②Cement-water glass double-liquid slurry: its ratio is W: C = 1: 1, C: S = 3 ~ 4: 1 (volume ratio); the modulus of water glass is 2.4-3.4, and the concentration is above 38Be', Gel time <60s. When the surrounding rock is broken on site, the grouting slurry can be adjusted according to the specific conditions on site.

### 4.2 Grouting pressure

The initial proposed grouting pressure is 1-2MPa. In order to ensure the safety of the pipeline above the tunnel and the grouting effect, the grouting pressure should be determined through field tests.

### 4.3 End standard of grouting

Adopt "quantity, pressure" double control grouting end standard, when the single-hole grouting pressure reaches the design final pressure and continue to grouting for more than 10 minutes, the grouting in this hole can be ended; when the grouting pressure does not reach the design final pressure and single-hole grouting When the slurry volume reaches 150% of the designed grouting volume, the grouting in this hole can be ended. In addition, when the amount of surface uplift exceeds the specified value during the grouting process, the grouting should be stopped immediately and the grouting parameters should be adjusted.

### 4.4 Grouting process

The grouting technology adopts forward or backward segmented grouting technology, and the grouting technology can be flexibly adjusted according to the hole formation conditions on site; in order to ensure the formation of deep hole grouting and the effect of the slurry and grouting reinforcement, the grouting parameters should be Adjust according to the field test. If the grouting effect does not meet the design requirements, supplementary grouting should be carried out.

Before the grouting construction, the location and elevation of the municipal pipeline must be confirmed, and the positional relationship between the grouting borehole and the pipeline must be verified to ensure that the clear distance between the grouting borehole and the pipeline is not less than 1.5m. During the construction process, pay attention to the protection of municipal pipelines, strengthen monitoring and measurement to ensure pipeline safety.

## 5. Grouting effect checking

Through the inspection hole, parameters such as formation permeability and surrounding rock integrity can be obtained. After the grouting is finished and allowed to stand for 1d, inspection hole construction can be carried out. A total of 9 inspection holes are set up per cycle. After grouting reinforcement, the water quality of the inspection hole is basically It is in a state of no water or slow

dripping water, and the formation permeability coefficient is less than  $1 \times 10^{-4}$  cm / s, which fully meets the requirements of tunnel water seepage. In the inspection hole, the borehole TV is used to observe the surrounding rock through the camera to visually judge the integrity of the formation, the grouting and solid cementing situation, the location of the water gush and the reason for the water gush. The borehole exploration results before and after grouting are shown in Figure 7.11. Before the grouting, the stratum was not reinforced, the formation integrity was poor, and there were many slumps in the borehole; after the grouting, the TV results showed that the integrity of the grouting and solids was significantly improved. Hole condition, the effect of grouting on the sand layer is very significant.



Figure. 7 Exposure groutingslurry in tunnel palm face

## 6. Conclusion

This paper takes the subway crossing the water-rich sand layer as the research background, and uses the advanced grouting reinforcement method to pre-grouting the sand layer within 12m in front of the palm face. The main conclusions are as follows:

(1) Advance grouting reinforcement can effectively enhance the cohesion between the sand layers, improve the compressive strength of the sand layer, and ensure the stability and safety of tunnel excavation;

(2) Keeping a 3m slurry stop wall can avoid the disordered diffusion of the slurry and ensure the retention rate of the slurry;

(3) The advanced curtain grouting method was successfully applied to the subway station. There was no collapse or other accidents during the excavation process. The overall excavation process is orderly and stable, which can provide some reference value for similar projects.

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