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# Construction technology of the freezing method for the connecting-passage in the subway

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**Abstract.** Taking the subway shield tunnel of Dagengjia Station to Longchuan Road Station of the first phase of Harbin Rail Transit Line 2 as the background, the freezing construction scheme and construction of the interval connecting-passage were introduced. The analysis and monitoring data show that the maximum settlement of the ground caused by the construction of the freezing method is -5mm, the maximum ridge is 6.12mm; the maximum settlement of the underground pipeline is -5.51mm; the maximum settlement of the connecting-passage is -7.13mm, the convergence value The maximum is 1.80mm, which is less than the construction control value and meets the construction requirements.

## 1. Introduction

The construction risk of subway tunnels mainly exists in the two stages of tunneling and connecting-passage construction. The connecting-passage accidents are more common. The subway tunnel connecting-passage is generally located in the middle of the upper and lower section of the tunnel. It is often combined with the pumping station. It not only serves as a liaison, but also plays a role of water collecting and drainage. It is an important part of the tunnel civil engineering [1-2]. The freezing method has the advantages of good waterproof effect and little influence on the surrounding environment. It shows unique advantages in municipal engineering, especially in the construction of soft water-bearing formations [3-5].

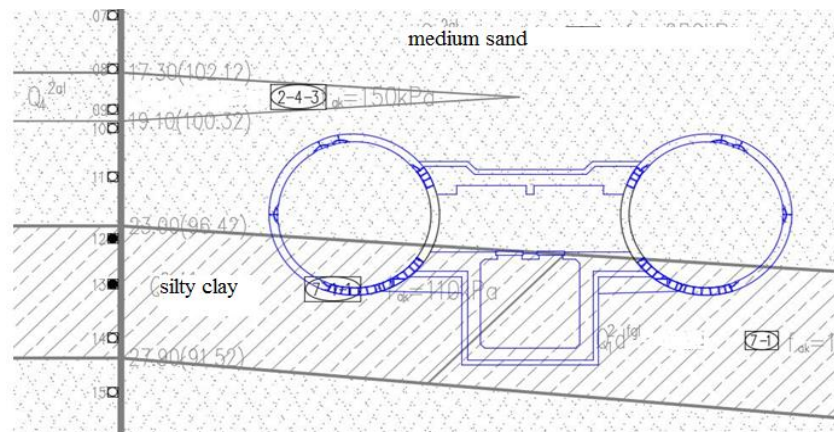
In the municipal tunnel project, the communication channel and the pumping station are often combined and constructed. Therefore, it is generally necessary to consider the construction of the frozen soil during the freezing method [6]. Harbin Dagengjia Station to Longchuan Road Station connecting-passage is constructed by the freezing method. This paper introduces the construction scheme of the freezing method in detail, and analyzes the safety of the construction with the monitoring data.

## 2. General situation of Engineering

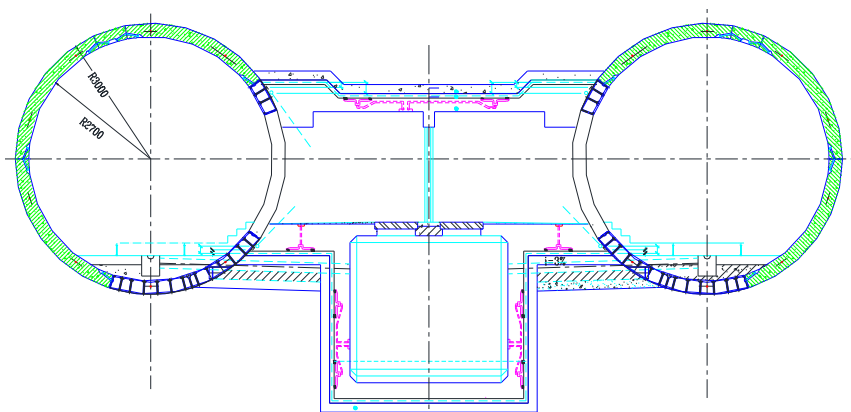
Harbin Rail Transit Line 2 Dagengjia Station to Longchuan Road Station is located on the north bank of Harbin Songhua River. The landform unit is the Songhua River floodplain. The ground elevation is 118.0~120.5m, and the terrain is gentle. This section sets up a connecting-passage, a connecting-passage



with a pump station. The freezing method is planned according to the design requirements. The main geotechnical layers of the site are surface mixed fill and plain fill, and the upper part is fine sand. The middle is mainly composed of clay soil with uneven thickness and thin sand. The lower bedrock is a Cretaceous mudstone with a buried depth of 47.70~48.70m and continuous distribution. The top of the 1# connecting-passage and pumping station is 20.4m deep, and the stratum is mainly composed of medium sand and silty clay. The geological section of the 1# connecting-passage and the pumping station is shown in Figure 1. The structure is shown in Figure 2.



**Figure 1.** The location of 1# connecting-passage and the pumping station



**Figure 2.** Structure diagram of 1# connecting-passage and the pumping station

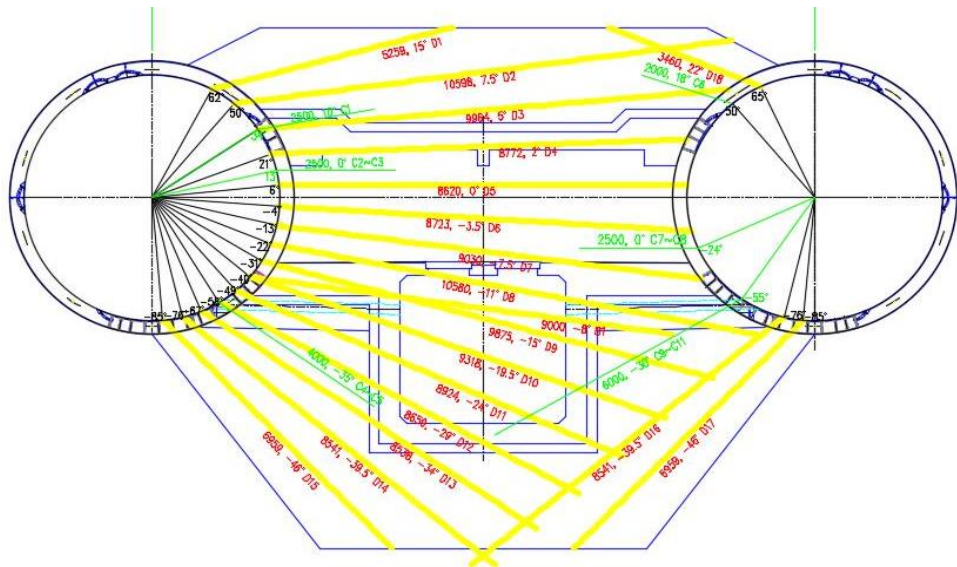
### 3. Construction process of freezing method communication channel

#### 3.1. Construction plan for freezing method

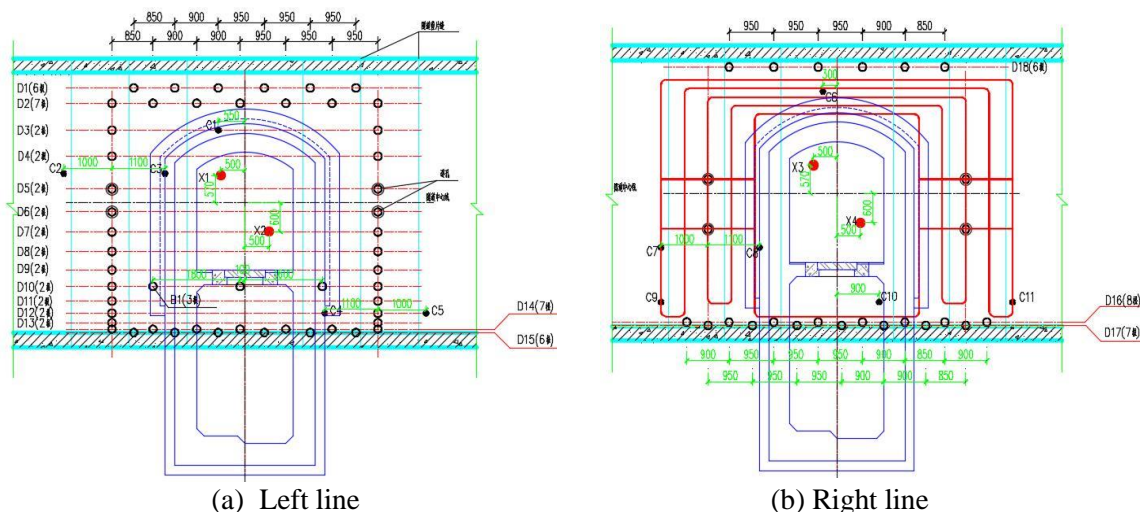
The design index of the strength of frozen soil is that the compressive strength is not less than 4 MPa, the tensile strength is not less than 1.8 MPa, and the shear strength is not less than 1.5 MPa ( $-10^{\circ}\text{C}$ ). 1# connecting-passage and pump station design the effective thickness of the frozen wall is 2100mm. On the outer peripheral circle of the excavation area, the average temperature at the junction of the frozen wall and the tunnel segment is not higher than  $-5^{\circ}\text{C}$ , and the average temperature of the frozen wall in other parts is  $-10^{\circ}\text{C}$ .

According to the frozen curtain design and the structure of the connecting-passage, the freezing holes are arranged around the connecting-passage and the pump room at three angles of up, horizontal and down. There are 72 freezing holes in the 1# connecting-passage and pump room, including 11 temperature measuring holes, 4 through holes and 4 pressure relief holes. There are 51 freeze holes on

the left line and 21 freeze holes on the right line, as shown in Figures 3 and 4. 2# connecting-passage designs 61 frozen holes, including 11 temperature measuring holes, 2 through holes, and 4 pressure relief holes. There are 40 freeze holes on the left line and 21 freeze holes on the right line. Freezing holes opening should avoid pipe joints, bolts, main ribs and steel sheet ribs. The hole in the bottom of the connecting-passage and the pump room is in the shape of a "V". When the freezing hole is constructed, the amount of soil loss shall not be greater than the volume of the freezing hole. Otherwise, the grouting shall be carried out in time to control the settlement of the stratum. A  $\phi 120\text{mm}$  diamond core drill is used for the freezing holes opening on the tunnel segment. The  $\phi 89 \times 8\text{mm}$  low carbon seamless steel pipe used for the freezing pipe has a length of 1.5 to 2 m for a single pipe and a length of 1.0 m for a final closing



**Figure 3.** Perspective view of the freezing hole of the 1# connecting-passage and pump room

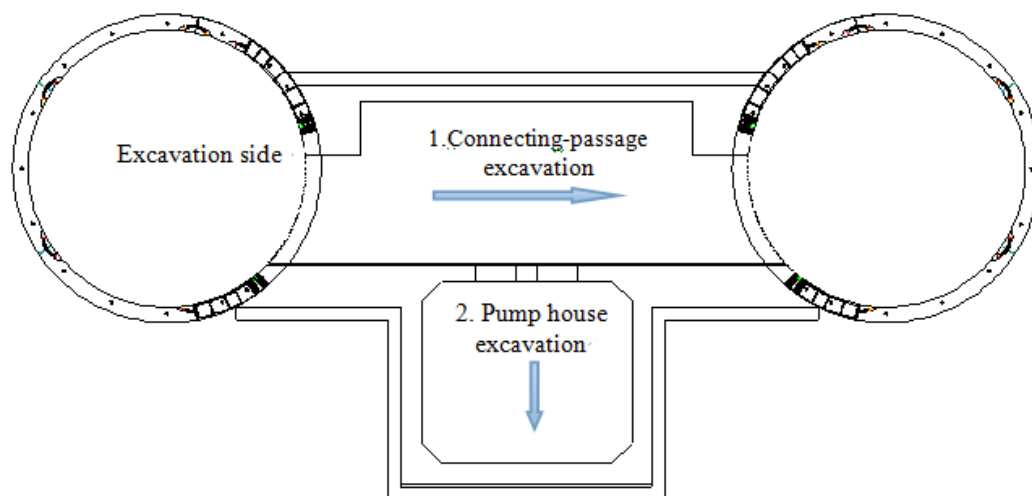


**Figure 4.** Arrangement of freezing hole opening position

### 3.2. Excavation of the connecting-passage and pump room

The connecting-passage is excavated from the left line, as shown in Figure 5. A pre-stressed support frame must be installed in the tunnel before the opening of the connecting-passage. The excavation of

the main body of the connecting-passage adopts a short step excavation method. The excavation cycle is 0.5m, and the step length is 2.5m. The upper step is excavated in zone I, the height is 1.5m, the lower step is excavation in zone II, and the height is 2m. The excavation and rock breaking is carried out by manual cooperating with the wind, and the initial support operation is carried out immediately after each excavation is completed. The initial support system is composed of grille steel frame, double-layer steel mesh and concrete. After the waterproof layer is laid, the concrete lining of the connecting-passage is poured. The pouring sequence of concrete is bottom plate, side wall, vault, pump house floor, pump house side wall, pumping room cover. After pouring the concrete lining, the freezing can be stopped and the freezing tube can be cut off. The freezing tube needs to be filled with grouting and anti-seepage treatment



**Figure 5.** Sequence of the connecting-passage and pump room

#### 4. Monitoring analysis

During the construction process, the surrounding surface settlement, pipeline settlement, connecting-passage vault settlement and clearance convergence deformation of the connecting-passage are monitored. There are 33 surface monitoring points for each connecting-passage in Dagengjia Station to Longchuan Road Station, 6 pipeline monitoring points, 3 connecting-passage convergence monitoring points, and 3 connecting-passage vault monitoring points. Real-time observation is carried out according to the actual situation on site. The monitoring results of the 1, 2# connecting-passage are shown in Tables 1 and 2.

**Table 1.** Statistical table of 1# connecting-passage construction monitoring results

| Number | Type of monitoring      | Number of monitoring points | Cumulative maximum point | Changed value(mm) |
|--------|-------------------------|-----------------------------|--------------------------|-------------------|
| 1      | Surface settlement      | 33                          | DBCL046                  | -5.00             |
|        |                         |                             | DBCL050B                 | 6.12              |
| 2      | Pipeline settlement     | 6                           | GXCL009                  | -4.94             |
| 3      | Vault settlement        | 3                           | GGC-L006                 | -7.13             |
| 4      | Convergence deformation | 3                           | GGJ-L005-2-4             | -1.60             |



**Table 2.** Statistical table of 2# connecting-passage construction monitoring results

| Number | Type of monitoring      | Number of monitoring points | Cumulative maximum point | Changed value(mm) |
|--------|-------------------------|-----------------------------|--------------------------|-------------------|
| 1      | Surface settlement      | 33                          | DBCL09<br>DBCL025        | -2.59<br>5.51     |
| 2      | Pipeline settlement     | 6                           | GXCL007                  | -5.19             |
| 3      | Vault settlement        | 3                           | GGC-L004                 | -6.60             |
| 4      | Convergence deformation | 3                           | GGJ-L01-2-4              | 1.80              |

During the construction of the connecting-passage, the ground settlement control value is 30mm, the uplift control value is 10mm, the underground pipeline settlement control value is 15mm, the contact channel dome settlement control value is 20mm, and the convergence control value is 12mm. It can be seen from Tables 1 and 2 that the maximum settlement of the ground caused by the construction of the freezing method is -5 mm, which is 16.7% of the control value settlement. The ground uplift value is 6.12mm, which is less than the control value of 38%, and the construction is safe. The freezing method is used to reduce the temperature of the soil layer of the construction section and freeze the soil layer to meet the requirements for improving the strength of the soil layer. The soil layer contains water, so the volume expands after freezing, and the construction will cause the ground to rise. And tracking the excessive grouting pressure during the construction process will also cause the ground uplift, so strengthening the monitoring can effectively guide the adjustment of the construction parameters. The maximum settlement of the underground pipeline is -5.19mm, which is 34.6% of the control value. The construction effectively controls the settlement of the existing pipeline.

After the initial support of the connecting-passage is completed, the waterproof layer is laid and the concrete structure layer is poured, the maximum settlement value of the vault of the connecting-passage during construction is -7.13mm, and the clearance convergence deformation is 1.8mm. The freezing method effectively controls the clearance of the communication channel. The maximum settlement of the dome is 35.7% of the control value, and the maximum value of the clearance is 13.3% of the control value, which effectively reduces the deformation of the communication channel.

## 5. Conclusion

Before the construction of the connecting-passage, the soil layer is strengthened by the freezing method to improve the strength of the soil layer, which can effectively control the settlement of the soil layer during the excavation process and the structural safety of the main body of the connecting-passage. Two connecting-passages are set up in the section of Dagengjia Station to Longchuan Road Station of Harbin Rail Transit Line 2, and the 1# connecting-passage is built with the pump house. The freezing method effectively controls the influence of excavation on the settlement of the surface and pipeline during construction, and reduces the structural deformation of the connecting-passage itself. In this construction, the maximum value of the ground surface is 6.12mm, the maximum settlement value of the pipeline is -5.51mm, the maximum settlement of the connecting-passage is -7.13mm, and the maximum convergence value is 1.80mm, which is less than the construction control value. The construction of the freezing method can ensure the safety of the excavation of the communication channel.

## Acknowledgments

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