Research on Comprehensive Analysis Method for Leakage Treatment of Underground Engineering Lining

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Abstract: The number of tunnel lining leaks is currently increasing during construction and operation. Through the comprehensive analysis of the system, the fundamental method for solving the leakage problem of the lining is explored. Through the repeated occurrence of seepage water leakage in the lining of Jinggangshan Station of Qingdao Metro, a set of system leakage water treatment methods was proposed, from pre-grout preparation, general cement slurry treatment, superfine cement slurry focus, chemical slurry replenishment. The lining aesthetics restores the five processes for treatment, and the five steps are integrated to achieve the effect of radical cure. And through field practice to verify, the method is highly feasible and the governance effect is good. It has strong applicability to the leakage of underground engineering lining, and can better solve the difficult problem of the lining leakage water that is currently faced.

1. Introduction
With the rapid development of the national economy, urban rail transit and large underground shopping malls have entered a period of rapid rise. The quality of underground engineering is an important key to its function, and the leakage of underground engineering is an important factor that seriously affects the quality of underground construction and threatens the normal operation of underground engineering. Therefore, the leakage problem of underground engineering is a key problem to be solved urgently.(Cao.2017; Li et al.2017).

At present, the research on the leakage control of underground engineering is not comprehensive, and the related research has a lag. Ye et al. developed a new type of plugging material by adjusting the amount of isocyanate and epoxy resin in the synthesized cyanide prepolymer and by selecting and combining various additives.(Ye et al.2003). Zhang et al. developed a new type of drainage material and conducted field test on the treatment of leakage of highway tunnels. (Zhang et al.2013). Cai et al. Application of cement-based permeable crystalline waterproof material in tunnel leakage treatment. (Cai et al.2009). Sha et al. analyzed the requirements of grouting materials for grouting treatment of leakage tunnels during operation period, and analyzed common Portland cement, cement-water glass, ultra-fine cement and polymer cement for different types of leakage water. (Sha et al.2016). Wang et al. carried out research on the prevention and control technology of seepage water in the Mingcai high-speed railway tunnel in Fushui District, and adopted the measures of partition waterproofing on
the main structure of the tunnel, which improved the waterproof ability of the tunnel in the later operation. (Wang et al. 2015). Peng et al. through the classification and rectification of the railway operation tunnels in the cold area, the construction technology of blocking and discharging and the anti-blocking materials of Ma Lisan were used for field test. (Peng et al. 2010). Liu et al. aiming at the seasonal leakage water diseases of a high-speed six tunnels, through field investigation, disease monitoring, combined with disease causal analysis, disease judgment grading and disease remediation research, the damage of various types of leakage water is analyzed, and the water leakage conditions at different periods and corresponding disease remediation measures are proposed. (Liu et al. 2015). Yang et al. analyzed the causes of leakage water in tunnels and formed a set of classification criteria. (Yang et al. 2017).

In summary, the current research is mainly focused on the analysis of leakage causes and the development of new materials. There is no effective and systematic treatment method for the treatment of seepage water, resulting in leakage of underground works during the existing construction period and operation period. Water disasters occur frequently and are difficult to handle and easy to repeat. In view of this, this paper relies on the repeated leakage problem of Jinggangshan Road Station in Qingdao Metro, and proposes a systematic leakage water treatment method, which is to be treated from five stages: pre-preparation, comprehensive treatment, key focus, supplementary reinforcement and lining recovery. This method achieves the effect of radical cure. Through practice verification, the method has high feasibility and good governance effect. It has strong applicability to the leakage of underground engineering lining, and can better solve the difficult problem of the lining leakage water that is currently faced.

2. Project Overview

Jinggangshan Road Station is the interchange station of Line 1 and R3. The station calculates the effective station center mileage as right YCK7+680, the starting mileage is right YCK7+589.589, the ending mileage is right YCK7+831.989; the total length is 242.4m, and the platform width is 15.5 m. The structural type is a three-layer three-span box-type frame structure system. The elevation of the station floor is -19.70m, the buried depth of the foundation floor is about 25.03m, and the depth of the roof is 3.5m. The main structure of the station is constructed by open cut method. The station has a total of 6 entrances and exits, and 4 wind tunnels. The ancillary structures are constructed by open cut method.

![Figure 1. Jinggangshan Road Station Traffic Location Map](image)

About 35m east of Jinggangshan Road Station is Liqun Group Supermarket, and the west side is adjacent to the new Roman holiday foundation pit under construction by Kaifa Group. The ground conditions are more complicated. The landform type of the site is mainly the coastal marsh zone in the coastal accumulation area.
3. Analysis of the cause of leakage
After several on-site surveys and combined with engineering hydrogeological data, the reasons for the leakage of the lining of Jinggangshan Road Station are as follows:

(1) The construction unit neglects the problem of leakage of water in the initial support, and has not carried out comprehensive treatment, resulting in the infiltration of bedrock fissure water to form leakage water supply.

(2) The foundation pit retaining structure adopts the pile anchor system, and the design stop water adopts the jet grouting pile water stop curtain. When the prestressed anchor cable is constructed, the water stop curtain of the retaining structure is broken to form the passage of the infiltration of the external groundwater.

(3) The structural concrete is rigid and self-waterproof, and the concrete structure is not tightly produced to produce the original cracks, forming the initial water seepage channel. As time increases, the concrete deteriorates and the water seepage channel increases.

(4) The flexible waterproof layer is partially destroyed, resulting in the infiltration of external water sources. The flexible waterproof layer is damaged, probably because: a, the weak link of the flexible waterproof layer is cracked under the action of groundwater; b, the flexible waterproof layer is perforated and destroyed due to concrete defects; c, the pre-packaged anti-adhesive flexible waterproof protective layer Damage or deformation causes local damage to the waterproof layer.

4. Comprehensive governance route
In view of the above difficulties, on the basis of making full use of existing engineering hydrogeological data and actual site surveys, the following work was carried out, and the causes of leakage of the lining of the station and the water guiding channel were systematically analyzed to lay the foundation for the treatment of leakage water. The technical route is as follows:
5. Comprehensive management plan

5.1. Preliminary preparation

(1) When the east and west entrances and exits of the station are in external precipitation, they are a natural water guiding channel that penetrates into the station lining. Therefore, it is proposed to first clean the east side fertilizer trough, especially the two or three layers of the junction area, to lay the waterproof coil material (or the application of waterproof coating), as far as possible to prevent the infiltration channel of the external water source. The details are shown in the figure below.

(2) For the outer surface of the west side lining, the outer surface of the intersection of the second and third floors of the subway station, pour the triangular asphalt diversion bar, as shown in the following figure, to avoid natural precipitation and so on.
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5.2. Comprehensive governance

5.2.1. Grouting scheme

According to the seepage condition of the lining of the site, in order to minimize the seepage area and the amount of water seepage, it is proposed to grout the grouting scheme of the lining wall of the side wall of the station to achieve the overall treatment effect. The construction area is selected on the inside of the station to ensure that the construction process is not affected by the weather.

The hole is drilled horizontally, and the waterproofing plate is pierced from the inner side wall of the station for grouting. The single side wall has a total of 3 sequence holes, which are E1-1~E1-13, E2-1~E2-13, E3-1~ E3-13 (a total of 78 holes), the hole spacing is 10m, the lowermost hole is 1m from the bottom plate, the uppermost hole is 1.2m from the top plate (considering the height of the rail
exhaust duct is 0.9m), and the hole depth is designed to be 1m (breakthrough) The waterproof board can be used. The specific drilling arrangement is as shown in the red punctuation shown in the figure below. The construction personnel should adopt the method of jump hole grouting, and the overall sequence of grouting should be taken from the bottom to the top.

5.2.2. Grouting equipment
In order to cooperate with the treatment of lining leakage water, a grouting sleeve device capable of conveniently processing the end is developed. The device is divided into a pre-grouting pipe, a slurry-expanding rubber sleeve and a direct, intermediate grouting pipe, and a slurry feeding machine, and pipe line four-way device and pipe head cover part. The pre-grouting pipe is a common steel pipe with an inner wire at one end; the anti-slurry expansion rubber sleeve is directly on the outer wire with the outer wire at both ends, and the middle grouting pipe is a stainless steel pipe with inner wire at both ends, one end is connected directly, and the other is directly connected. One end is connected to the slurry pipeline; the four-way device of the slurry pipeline is a stainless steel four-way device with an inner wire at one end and a valve at each port, wherein the three-terminal ports are a slurry A port, a slurry B port and a pressure relief port; The pipe head cover is a circular wire plugging device with an outer wire at one end, and the front grouting pipe can be sealed after being screwed.

5.3. Key governance
The drilling is horizontally drilled, and the waterproofing board is pierced from the inner side wall of the station lining for grouting. The single side wall has a total of 3 order holes, respectively C1-1~C1-12, C2-1~C2-13, C3-1~C3-12 (a total of 78 holes), the hole spacing and other parameters are the same as above, the specific drilling arrangement is shown at the black punctuation as shown above.
5.4. Supplementary reinforcement
After the above processes are completed, most of the areas can be completely blocked by the leakage water. For the remaining water seepage area, chemical slurry is planned to be used for treatment. Including the construction joint and the roof seepage area, the hole spacing is designed to be 15cm, and the hole depth is designed to be 20cm. The details are shown in the figure below.

6. Governance outcome analysis
After the end of grouting and surface recovery, the leakage of the side wall of the lining of the station can be observed to disappear, and the station meets the acceptance criteria. No recurrences were found after one week.
7. Conclusions

(1) Through detailed investigation of the original engineering geological data and site conditions of Jinggangshan Road Station, the researchers determined the causes of leakage in the lining of the station and obtained key information such as the seepage path inside and outside the station. So that we can prepare for the lining leak treatment.

(2) The researchers developed a convenient grouting sleeve device, which realized convenient handling of the tip, reuse of the device, and rapid recovery of the wall surface, greatly improving the work efficiency and reducing the cost, and can be used in grouting construction. It is widely used.

(3) A comprehensive treatment method for lining leakage water is proposed. The cement slurry is fully treated to achieve the plugging of leakage in most areas. And the ultra-fine cement focuses on the treatment to achieve complete sealing of the remaining water outlets in the leakage area. And the modified epoxy resin is supplemented and strengthened to achieve the seepage of the lining surface. Completing eradication of the area. This method solves the shortcomings of the existing governance methods lacking systemicity, poor governance effect, and easy repeated leakage, achieving triple protection, fundamental governance, and providing reference for similar projects.

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