Research on the Treatment Plan for Anchor Ropes in the Construction of Subway Bored Pile

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Abstract. This study primarily explores treatment solutions for anchor cables encountered during the construction of subway bored piles. As pile anchor forms become prevalent in foundation pit support for high-rise buildings, the intersection of subway lines with existing anchor cable areas poses considerable challenges. The study aims to develop practical and feasible anchor cable treatment plans to facilitate efficient, economical, and safe completion of subway station and other open-cut retaining structures. Taking the Youyi South Street Station of Shijiazhuang Metro Line 4 as an example, through comparative analysis of different treatment schemes, the optimal approach is identified, providing valuable references for similar engineering projects.

Keywords: subway station drilling and grouting pile anchor cable treatment plan, reference significance

1 Introduction

As cities continue to expand, the construction of subway projects has intensified in large and medium-sized metropolises. In northern regions, pile anchor forms are primarily used for foundation pit support in construction projects. However, due to planning constraints, the relationship between new subway projects and existing anchor cables is often overlooked. Because of the dense buildings in the city, the subway construction will inevitably encounter the problem of alternating anchor cable and foundation[1-5]. This study, leveraging the construction of the retaining structure at Youyi South Street Station on Shijiazhuang Metro Line 4, conducts a comparative study of anchor cable treatment schemes during bored pile construction, aiming to provide insights for future practices.

Z. Zhang et al. (eds.), *Proceedings of the 2024 6th International Conference on Structural Seismic and Civil Engineering Research (ICSSCER 2024)*, Advances in Engineering Research 246,
https://doi.org/10.2991/978-94-6463-556-0_14

2 Project Overview

2.1 Project Introduction

The Youyi South Street Station on the Shijiazhuang Metro Line 4 is designed as an underground double-layer island station featuring a unique structural layout. Specifically, it incorporates a single column, double span, and double column, three span frame structure in both the public and equipment areas. This station boasts four entrances for passenger convenience and two wind pavilions for added functionality. Geographically, the station spans from K4+495.625 to K4+715.625 along its route. The effective platform center mileage is precisely located at K4+641.475, ensuring optimal positioning for commuters. The buried depth of the station's center mileage rail surface is approximately 16.651 meters, demonstrating its substantial underground presence. The main structure foundation pit of the Youyi South Street Station is substantial in size, measuring 220.20 meters in length. Its depth varies between 18.13 meters and 20.93 meters, accommodating the complex geological conditions of the site. Additionally, the width of the foundation pit ranges from 19.9 meters to 23.8 meters, covering an excavation area of 4458.1m^2, providing ample space for the station's infrastructure. Overall, the Youyi South Street Station is a well-planned and strategically located underground station, designed to cater to the transportation needs of the community while adhering to rigorous engineering standards.

2.2 Engineering Geology and Hydrological Conditions

According to geological survey data, this site area is divided into miscellaneous fill, plain fill, loess like silt, fine sand, medium coarse sand, silty clay, silt, and fine sand layers from top to bottom. The base is located in fine sand. The standard depth of the foundation pit is 20m, and the groundwater depth is 23.7m.

2.3 Surrounding structures

The northwest quadrant of the station is a 17 story building of Shijiazhuang Children's Hospital (Maternal and Child Health Hospital) (with a frame shear wall of 17F and a 3-story raft foundation buried at a depth of 14.7m), the southeast quadrant is a 12 story building of St. Lujia Maternity and Child Health Hospital (with a frame shear wall of 12F and a 1-story basement buried at a depth of 4m with a raft foundation), and the northeast side is a 5-story building of Hebei Foreign Studies University (with a brick concrete structure of 5F and a 3-meter strip foundation buried at a depth). The surrounding environment is shown in Figure 1

Fig. 1. Surrounding Buildings Situation

3 Research on the Scheme of Drilled Cast-In-Place Piles

The enclosure structure of this station adopts a two story station with a diameter of 800@1300mm The support type of drilled cast-in-place piles (with a diameter of Ø at the expanded end of the shield tunnel and the adjacent Lingtang of Xiwulizhuang) 800@1200mm Drilled cast-in-place piles are constructed using the open cut and chamfering method. The small mileage section of the station is constructed using shield tunneling method, while the large mileage section is constructed using hidden excavation method. A shield tunneling receiving shaft is installed at the small mileage section of the station.

3.1 Test Pile Driving Before Pile Foundation Construction

According to the drawings and geological survey data of this project, before actual construction on site, test pile driving shall be carried out on the sand layer, pile length greater than the groundwater level, pile length less than the groundwater level, and pile foundations within the range affected by anchor cables. Construction methods shall be selected to meet the actual needs of the site. However, the pile foundations within the range affected by anchor cables shall be constructed using mud wall protection method to prevent the collapse of the hole wall caused by the pulling of the anchor cable during the treatment process.

3.2 Impact of Anchor Cables on Pile Foundation Construction

There are a total of 406 retaining piles in the station, including 255 Phase I retaining piles (including 15 isolation piles) and 151 Phase II retaining piles. Among them, there are 12 fiberglass reinforcement piles at the small mileage end. There are 104 Phase I pile foundations located within the anchorage range of the underground garage of the Municipal Children's Hospital, and each pile foundation needs to handle 3 anchor cables, as shown in Figure 2. Three anchor cables are driven from top to bottom at a 15 ° angle to the underground. The top layer has a total length of 22 meters, including a 15 meter anchorage section and a 7 meter free section; The total length of the second and third tracks is 20 meters, including a 15 meter anchoring section and a 5 meter free section.

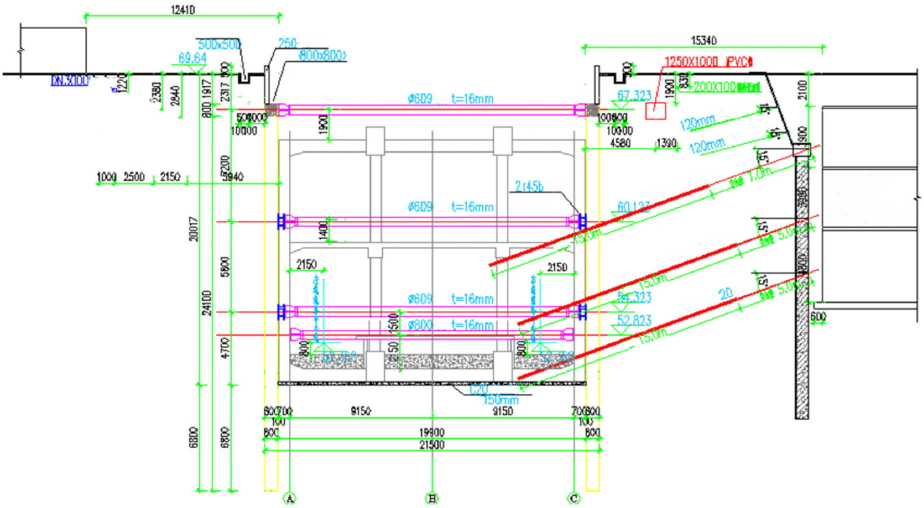

Fig. 2. Relationship between Anchorage and Station Location of Children's Hospital

3.3 Comparison and Analysis of Anchor Cable Treatment Schemes

Due to the proximity of Exit D of Friendship South Street Station Station to the basement of the existing Children's Hospital (three underground floors and 17 above ground floors), the foundation is a raft foundation with a burial depth of approximately 14.7 meters; The horizontal distance from the D entrance and exit pit is about 5.47m, and the depth of the pit here is about 10m, which is very close to the pit. Abandoned anchor cables in the foundation pit of children's hospital buildings may invade the scope of the foundation pit, affecting the construction of the foundation pit pile foundation and posing a risk of drilling jamming. Geophysical exploration should be conducted in advance before the installation of later retaining piles to explore the position of surrounding anchor cables. Pile foundation installation should try to avoid the range of anchor cable installation. During the construction process, the following methods can be used for handling:

(1) Open cut method: This is a traditional construction technology with mature technology and high controllability. After the existing traffic is cleared, it is expected to open cut the anchor cable section within the enclosure, with a depth of about 20m. The pit wall is supported by an underground continuous wall, which has low construction risk and can also eliminate other unknown obstacles (such as H-shaped steel and abandoned pile heads). The anchor cable can be completely removed. But this area is located in the bustling downtown area. If enclosure and open excavation are carried out, it will

seriously affect the normal traffic of the existing main road. There are also many existing pipelines, and relocation is very troublesome. The construction period is long, and the enclosure piles will form new obstacles for the shield tunneling.

(2) Drilling rig friction reduction sleeve method: Open trench excavation is carried out in the expected anchor cable section, and after the excavation anchor head is exposed, the anchor cable drilling rig is used to drill the entire pipe to reduce friction and then the anchor cable is removed. Firstly, this process also requires occupying most of the motor vehicle lanes in the construction area and requires large-scale pipeline relocation, and the on-site conditions are basically not available for implementation. Secondly, due to the maximum length of the anchor cable reaching 22m, during the friction reduction process, the anchor cable drilling machine is prone to bending, deformation, and construction errors due to the anchor cable being too long, which can easily lead to the phenomenon of cutting the anchor cable. This will result in the remaining anchor cables being unable to be completely removed, and it is easy to miss the anchor cable, which is not thoroughly removed, thereby affecting shield tunneling and posing great safety risks.

(3) Vertical cable cutting method using full casing rotary drilling rig: In areas with anchor obstacles in the shield tunnel section, a 1.5m diameter full casing rotary drilling rig is used to drill and cut the cable, and then low-grade mortar is used for backfilling. Triple tube high-pressure rotary jet grouting piles are used to supplement and reinforce the 1.5m diameter piles. This technology is used for ground construction to minimize safety hazards as much as possible; No need for deep foundation pit excavation, reducing safety risks; No need for pipeline relocation, can be constructed in stages with minimal traffic impact; During construction, the disturbance to the surrounding soil is minimal and will not affect the surrounding pipelines and buildings; It can completely remove obstacles such as anchor cables.

(4) Rotary drilling method for cutting cables: 360 degree rotary drilling is used for breaking, with an aperture of 800mm and a spacing of 1200mm~1300mm. After the pile foundation points are placed, the casing is buried and drilled with slurry, using high-performance bentonite slurry. When the rotary drilling reaches the anchor cable, there will be a significant increase in torque and a stagnation in footage. It is necessary to repeatedly cut and pull, break the anchor cable, and then continue drilling until the end of the hole. To ensure the rigidity of the drilling bit, it is necessary to adjust the bit to an alloy steel bit before rotary drilling.

(5) Taking into account the construction site, rationality, economy, and safety, the station adopts the special alloy cylinder drilling cutting method and alloy steel rotary drill bit drilling construction method under this working condition. The project has achieved the expected results by comparing and studying the practice of two schemes, and using the alloy steel rotary drilling bit construction method for anchor cable treatment is more reasonable and effective. As shown in Figure 3.

Fig. 3. Schematic diagram of anchor cable breakage

4 Conclusions

This study identified the alloy steel rotary drilling bit method as the optimal solution for anchor cable obstacles during bored pile construction at Youyi South Street Station, Shijiazhuang Metro Line 4. While effectively addressing complex geological and environmental challenges, further research is needed to refine construction details and enhance efficiency. Future studies should explore long-term effects and potential improvements.

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