Journal of Architectural Research and Development, 2024, Volume 8, Issue 6
https://ojs.bbwpublisher.com/index.php/JARD
Online ISSN: 2208-3537
Print ISSN: 2208-3529

Application Strategies of Pipe Jacking Technology in Municipal Rainwater Pipeline Engineering

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Abstract: Traditional construction techniques have a significant impact on the environment and are associated with long construction durations in the construction of municipal rainwater pipelines. Pipe jacking technology, a new type of pipeline construction method, enables non-excavation construction and can address the shortcomings of traditional pipeline construction. This article analyzes the concept and application advantages of pipe jacking technology. Combining engineering examples, it explores the application strategies of pipe jacking technology in the construction process of municipal rainwater pipelines for reference.

Keywords: Municipal engineering; Rainwater pipeline; Pipe jacking construction

Online publication: November 28, 2024

1. Introduction

During the construction phase of municipal engineering, pipelines constitute an important aspect of the work. As a non-excavation pipeline construction method, pipe jacking technology has minimal impact on ground buildings and activities during its application. Therefore, it offers significant advantages in the construction of rainwater pipelines. However, the pipe jacking construction process also entails risks, requiring careful control of key points to ensure construction quality.

2. Overview of pipe jacking construction technology

2.1. Concept of pipe jacking construction technology

Pipe jacking construction technology, widely applied in municipal rainwater pipeline projects, falls under the category of non-excavation construction techniques. During the construction process, relevant managers and workers must conduct a detailed analysis of the potential negative impacts that the project may cause, necessitating continuous optimization and improvement of this technology. Additionally, the use of pipe jacking technology can reduce construction noise, minimizing disturbance to surrounding residents even during nighttime operations. While this method allows for deep underground work, its relatively high

research and development costs can somewhat increase overall construction expenses and extend the project timeline. Therefore, companies need to select and apply various pipe jacking techniques based on the specific environmental and geological conditions encountered during the actual construction process. Furthermore, the application of pipe jacking technology in municipal rainwater pipeline construction requires vertical alignment with the ground surface, aided by jacks, to establish a solid foundation for the project [1].

2.2. Advantages of pipe jacking construction technology

In recent years, the scale of urban development in China has been expanding continuously, with concurrent improvements in urban transportation and economy. However, many municipal rainwater pipelines in older urban areas still face issues such as leakage and aging, necessitating reasonable upgrades and renovations in densely populated regions [2]. The application of pipe jacking construction technology in municipal rainwater pipeline projects offers numerous advantages. It not only avoids many demolition steps but also ensures safety and stability during the construction phase. Moreover, it enables effective cost control and improves construction efficiency to a certain extent. Consequently, pipe jacking construction technology stands out as a preferred choice in current municipal rainwater pipeline projects [3].

Furthermore, the rational application of pipe jacking construction technology in municipal rainwater pipeline projects can minimize the impact of traditional construction methods. It reduces adverse effects on surrounding roads and vegetation, thereby enhancing the protection of the local ecological environment. Simultaneously, the construction activities have minimal impact on adjacent high-rise buildings and the daily lives of residents, minimizing the occurrence of engineering accidents and risks. As a result, this technology has gained recognition from numerous construction companies and the general public [4].

3. Application strategy of pipe jacking construction technology in municipal rainwater pipeline engineering

3.1. Project overview

This project starts at the inspection well of the new road and crosses the existing road to construct a municipal rainwater pipeline. However, through field investigations, it was found that there are various important pipeline facilities such as water supply pipelines, sewage pipelines, and gas pipelines near the existing road. Therefore, it is necessary to design and plan ahead of time based on actual conditions before the construction work begins, to ensure the smooth construction of the municipal rainwater pipeline project and avoid impacts on various pipelines. Additionally, geological survey results indicate that the pipeline construction of this project needs to cross the pebble layer. Due to the strong bearing capacity, strong water permeability, and resistance to deformation of the pebble layer, the open hand-dug jacking method needs to be applied to carry out the construction work [5]. Furthermore, due to the high traffic volume on the road, it is also necessary to consider the disturbance to the ground during the construction process and coordinate with relevant departments to semi-close the road section to ensure smooth construction.

3.2. Introduction to engineering construction technology

3.2.1. Open construction technology

An important component of open construction technology is the hand-dug tool pipe. However, in practical applications, the hand-dug tool pipe involves direct excavation of the construction surface by construction workers. Before excavation, it is necessary to observe the local soil conditions and working surface and develop corresponding measures to address problems encountered during construction. Additionally, the hand-dug tool

pipe has advantages such as ease of application and low cost, but its main disadvantage is its high requirement for groundwater level. Therefore, detailed measurements and appropriate adjustments to the groundwater level are required before construction [6].

Moreover, the extruded tool pipe is also an important part of the open construction technology. Its main working principle is to disconnect the working surface using a breastplate. The extruded tool pipe is mainly a trumpet-shaped conical cylinder. When this tool is forcefully extruded, the main body is squeezed into the trumpet mouth, forming a long soil column through the trumpet mouth. When the soil column reaches a certain length, it can be cut off with steel wire and transported to the ground using soil transportation equipment. Therefore, through relevant research and practice, it can be understood that this method is more suitable for wet clayey soil, sandy soil, and large and medium-diameter pipelines. The extruded tool pipe also has advantages such as simple operation and safety [7].

3.2.2. Closed construction technology

In closed construction technology, the hydraulic cutting head is an important piece of equipment. Simultaneously, there is a sealed pipe in front of the head, which contains a mud suction port, high-pressure water gun, mud transportation pipeline, and grating. Additionally, a vertical hinge is installed on the sealed pipe to improve the flexibility of the tool. Therefore, when using the hydraulic cutting head, it is easy to separate the left and right deviations from the upper and lower deviations without mutual interference, and the deviation position can also be identified. Furthermore, it is necessary to adjust the hinge position according to the actual situation and different needs, to effectively meet the requirements of pipe jacking construction under various soil conditions.

4. Installation of pipe jacking construction equipment

4.1. Installation of guide rails

Before installing the guide rails, relevant staff should first check the center position of the pipeline and calculate the guide rail gauge to ensure that the centerline of the reserved hole overlaps with the centerline of the guide rail. Moreover, when selecting the guide rail, detailed analysis is required based on the pipe diameter. Since this project has chosen a crane rail, it is necessary to use railway nails to fix the guide rail [8]. Additionally, when setting the center elevation of the guide rail surface, it should be based on the designed elevation of the pipeline ditch bottom, while ensuring that the two have the same slope. This improves the stability and safety of the guide rail installation and ensures that problems such as deformation, displacement, or settlement do not occur during pipe jacking construction.

4.2. Installation of pipe jacking equipment

During the installation of pipe jacking equipment, a large crane is required to transport the jack to the preset position, and supports are needed to fix it. In the installation and fixing process, a jack should be set on each side of the pipeline, ensuring they are symmetrical on both sides. Since the jack cannot be directly applied to the pipeline for jacking, it is necessary to install a jacking iron to increase the contact area and disperse the stress to some extent [9]. Furthermore, the size and installation position of the jacking iron should be clarified according to actual needs, and when the jacking force is close to the compressive strength of the pipeline, it is necessary to appropriately add annular or U-shaped jacking irons.

5. Application of pipe jacking construction technology

5.1. Inspection before jacking

To ensure the overall quality of pipe jacking construction work, it is necessary to conduct pre-construction inspections. Firstly, all equipment should be inspected to ensure their normal operation. Secondly, all piping materials should be inspected to clarify their quality. Finally, the slope, centerline, and elevation of the guide rails should be checked to ensure they meet the actual requirements.

5.2. Jacking process

Firstly, in this project, manual excavation is mainly used for pipe jacking construction. The excavation work should be timely coordinated with the jacking operation to minimize jacking force limitations. Before excavation begins, the soil layer should be cut with a blade, followed by layer-by-layer excavation from top to bottom. During excavation, the excavation scope should be reasonably controlled to prevent collapse issues, thus ensuring the normal progress of pipe jacking construction. Additionally, relevant management and construction personnel should monitor the excavation situation in real time to avoid over-excavation, thereby minimizing the impact on the foundation and preventing pipe-end settlement. Furthermore, if the excavation area encounters a weathered rock, which is difficult to excavate manually, methods such as water drilling for coring or rock breaking with a pneumatic pick should be applied. The excavated soil should be promptly transported out using a four-wheel transport trailer to facilitate subsequent construction work [10].

Secondly, a crane should be selected based on the actual situation and requirements of the project to carry out pipe-lifting work, with manual assistance. During the construction process, nylon lifting belts should be used to fix both ends of the pipe, which is then placed in the working pit using the crane. It is important to note that the pipe-lifting process should be stable and slow. Workers should also use hemp ropes for traction to ensure the pipe remains stable. When lowering the pipe, the speed should be minimized to avoid damage and ensure project quality.

Thirdly, during the jacking process, the principle of "excavate first, then jack; excavate as you jack" should be strictly followed. In the initial stage of construction, the jacking speed should be reasonably controlled and kept as low as possible. Only after the pipe has been jacked a certain length and is tightly in contact with the soil can the jacking speed be appropriately increased. Additionally, after one jack is completed, detailed measurements should be taken. If deviations are found, timely corrections should be made, and jacking operations can only continue after installing the jacking iron. After jacking out one section of the pipe, the jack should be retracted. The next section of the pipe should be lifted into place and adjusted before continuing the jacking work. This process should be repeated until the jacking work is complete. During the jacking process, thixotropic mud can be injected around the pipe section to reduce resistance. If there are obstacles underground, reasonable methods should be used to remove them before continuing the jacking work. In case of special situations such as a significant increase in jacking force, jacking must be immediately stopped, and workers should promptly leave the pipe. The cause of the accident should be analyzed, and only after taking safety measures to eliminate the abnormality can excavation and jacking be resumed.

Then, during the pipe jacking construction, if the allowed total jacking force is lower than the jacking resistance and it is difficult to complete the jacking in one go, it is necessary to reasonably set up relay stations for segmented relay jacking. However, if the jacking exceeds a certain length during the construction process of this project, it is necessary to set up the relay station at the middle position of the pipe and divide the pipeline into two sections. The relay station mainly includes a jack, a rear shell, and a front shell, where the rear shell is connected to the rear pipe, and the front shell is connected to the front pipe, with the main connection method being a socket-type connection. Additionally, both the pipe section's outer diameter and the shell's outer

diameter have relatively high rigidity and strength, as well as manufacturing precision. During the jacking work, all jacks are reasonably arranged along the circumference and connected to the front shell using fasteners, forming a certain pushing force to jack the pipeline ahead of the relay station.

Finally, in the construction process of municipal rainwater pipeline engineering, the pipe interface is an extremely important component that can directly affect the construction quality. If not handled properly, it may even lead to pipe leakage problems. However, in this project, steel socket joints are mainly used. Therefore, during pipe lifting, it is necessary to avoid lifting through the pipe and instead use lifting belts at both ends of the pipe to prevent damage to the pipe socket. Before lowering the pipe, it is also necessary to timely clean the soil and debris at the socket position, put a rubber ring on the socket, and install a force transmission wooden pad. During the pipe-lowering process, attention should also be paid to transportation work, and the pipes should be placed as slowly as possible to reduce collisions, thus ensuring the safety of the pipeline. Only after the pipeline is placed can the jacking continue. After the pipe jacking work is completed, it is necessary to remove debris and soil from each socket joint, ensure that the entire pipeline has no leakage problems, and then use the specific sealing paste to fill the pipe joints to improve the overall quality of the project.

6. Grouting on the back of loose soil pipes

Due to the loose soil around the pipe jacking and the existence of gaps between the strata and the outer wall of the pipeline, it is necessary to perform back grouting on the completed jacked pipeline to achieve the purpose of compacting the gaps. This can also prevent pipeline leakage and sinking problems. In this project, the grouting holes are threaded pipe grouting holes set during the pipeline production process, and the grouting fluid used is double-liquid slurry. During grouting, it is necessary to install pre-made grouting pipe heads on the pipeline, and reasonably control the grouting volume and pressure. Only when there is a proper amount of slurry and grouting pressure in one grouting hole can the valve be closed. Finally, the grouting hole is sealed before continuing to the next grouting hole. The above operation is repeated until all grouting is completed.

7. Backfill construction and closed water test

Before carrying out pipe jacking construction, the corresponding machinery should be used for excavation. The quality of the working pit should be checked promptly, and only when it meets relevant standards and requirements can the next step of construction continue. Additionally, surrounding obstacles should be surveyed before pipe jacking construction, and backfilling should be performed at corresponding locations. Soil should be transported into the pit using transport vehicles and loaders, followed by leveling and compaction to improve the overall quality of the municipal rainwater pipeline project and provide convenience for people's lives.

8. Conclusion

In summary, the application of pipe jacking technology in the construction of municipal rainwater pipelines not only has a small impact on the environment but also high construction efficiency. During the practical application stage of the technology, technicians are required to proceed from reality, combining the hydrological and geological environmental characteristics of the construction area, and selecting technical application measures based on the actual needs of the project. They should standardize the technical application process, perform quality control work in construction links, leverage the advantages of pipe jacking technology, and provide support for the high-quality construction of rainwater pipeline projects.

Disclosure statement

The author declares no conflict of interest.

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