

# Discussion on the Application of Pipe Jacking Construction Technology in Municipal Road Drainage Projects

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**Abstract:** In the construction of municipal road drainage projects, pipe jacking construction is a relatively common construction method. This construction technology can avoid a large amount of excavation work, improve drainage construction efficiency, avoid large-scale damage to the road surface, and exert small traffic impact. Therefore, it is currently widely used in drainage construction, but judging from the current actual application situation, there are still many problems that require further improvement. This article mainly analyzes the advantages of and current technical problems in pipe jacking construction technology in detail, explores corresponding solutions, and lays a foundation for the optimization of municipal road drainage engineering construction.

**Keywords:** Municipal roads; Drainage projects; Pipe jacking construction; Advantages

**Online publication:** November 28, 2023

## 1. Introduction

Pipe jacking construction management in municipal road drainage projects is a key technical method to ensure the effective operation of urban drainage construction. In drainage projects, once there is a problem with the construction quality, or a relatively large impact area caused by the construction, it will affect the reputation of municipal enterprises and cause inconvenience in citizens' lives. Judging from the current pipe jacking construction technology model in municipal road drainage construction, the construction technology has been continuously improved and the construction field has been expanded, thus becoming an important technical method in trenchless construction of drainage projects. With the continuous development of pipe jacking construction technology, pipe jacking construction has entered a more advanced stage, and automatic deviation correction can be used to ensure the accuracy of pipe jacking construction and improve construction quality.

## **2. Advantages of pipe jacking construction in municipal road drainage projects**

### **2.1. Unaffected by the weather**

The main work of pipe jacking construction is completed underground, so it will not be affected by bad weather. Generally, if there is bad weather such as rain, snow, or ice during municipal construction, workers should stop their work and take a rest. Construction can only continue after the bad weather has passed. This construction method will inevitably affect the construction progress. Moreover, the extension of the construction period of municipal drainage construction will also have a serious impact on people's normal lives. Pipe jacking construction can effectively solve these problems. In addition to not causing large-scale road damage, it can also persist in construction in bad weather, avoid delaying the construction period, and reduce the impact on citizens' lives.

### **2.2. Less destructive underground facilities**

During pipe jacking construction, the land disturbance at the construction location is relatively small without large-scale damage. Most urban drainage pipes are built under buildings and traffic roads. Conventional drainage construction will inevitably affect the underground pipelines and other facilities. However, pipe jacking construction can prevent these problems. Pipe jacking construction can avoid other pipelines and obstacles through curves, without affecting the original lines, and at the same time, it will not interfere with residents' lives <sup>[1]</sup>.

### **2.3. Efficient and safe drainage pipeline construction**

The construction of some municipal drainage pipelines needs to pass through densely populated streets in the city center. Excavation in large areas will inevitably lead to ground damage and affect the normal operation of the city. One of the features of pipe jacking construction is that it allows construction without ground excavation. It does not involve traffic restrictions or demolition work, and the construction is safe, efficient, and has little impact on the environment.

## **3. Common problems in pipe jacking construction of municipal road drainage projects**

### **3.1. Significant deviation in the pipeline axis**

During the pipe jacking process, if there is a large deviation between the axis design and the actual axis, it will easily cause the pipe to bend, thus causing damage to the pipe sections or leakage at the interface. The main reason for this situation is that the resistance force on the front of the bottom layer during pipe jacking construction is uneven, which leads to a deviation of the pipeline guidance, resulting in a large deviation. It may also be that the back of the jacking pipe is uneven and displaced, causing abnormal movement of the resultant line. In addition, the jack construction during pipe jacking construction is not synchronized, or the gap between jacking forces is relatively large, resulting in limited installation accuracy and easily causing deviation of the resultant force.

### **3.2. Uneven ground**

During the construction of municipal road drainage projects, pipe jacking construction is prone to uneven ground around the construction axis, or uplift or settlement. In this case, the ground will be affected, and this will pose certain risks to the surrounding buildings and traffic, thus affecting normal life. The main reason for this situation is that the earth pressure of the tunnel boring machine is unbalanced during the pipeline

jacking process, which causes the ground to bulge or settle. During the operation of the earth pressure balance tunnel boring machine, the soil in the forward position needs to be cut and mixed. In this case, a relatively large amount of fluid soil will be formed in the soil bin. If the front soil pressure control is between active and passive pressure, it will cause the ground to bulge or settle. The underground soil quality will undergo relatively large changes during excavation. From the perspective of theoretical calculation, this control mode is prone to severe differences and is difficult to grasp effectively, because the uneven pressure causes uneven ground problems<sup>[2]</sup>. In addition, the control effect of earth pressure will be affected and lead to earth pressure instability if there are problems such as the earth pressure balance tunnel boring machine having insufficient adaptability to the earth pressure, unscientific adjustment during the cutting process, small area, etc. In addition, the gaps around the pipes can also cause uneven ground problems. The curved form of excavation or the correction of deviations will create gaps around the pipe. If the cross-section formed by the curve advancement is larger than the cross-section of the pipe, a large amount of soil will enter the surrounding voids, causing ground subsidence. Moreover, grouting is currently used in pipe jacking construction, and delayed grouting will also cause settlement. The friction between the pipeline and the surrounding soil will also cause unevenness in the ground. During the jacking process, the pipeline will form a relatively large friction force with the soil. This friction will cause disturbance to the original soil structure and lead to ground subsidence. Uneven pipe shape interface also increases the impact of disturbance. Leakage at pipe joints will also cause ground settlement due to water and soil erosion at the leakage location.

### **3.3. Large jacking force during pipe jacking construction**

A sudden increase in jacking force during pipe jacking construction will affect the construction quality. The main reason for excessive jacking force is that the soil collapses during the jacking process, or there are obstacles in the direction of jacking, etc., which increase the resistance to progress. Deviation of the management axis or curved route will also increase friction. In addition, the effect will also be affected if the ratio of the drag reduction medium during pipe jacking construction is improper, or if the mud is insufficient or not poured in time. If there is a long pause due to a problem during jacking construction, it will also affect the drag reduction ability.

## **4. Application of pipe jacking construction technology in municipal road drainage projects**

### **4.1. Preparation before construction**

Before starting the pipe jacking construction of municipal road drainage projects, relevant personnel must first go to the site to conduct construction surveys and understand the hydrology and geological environment of the construction site, as well as the distribution of surrounding buildings. After fully understanding the conditions of the construction site, corresponding construction plans should be formulated. Firstly, it is necessary to design construction drawings, strengthen construction inspection, and determine specific construction dimensions and burial depth. Then, improvements should be made based on the deficiencies in the drawings. At the same time, a large amount of construction equipment needs to be used in pipe jacking construction. In order to ensure the smooth progress of the construction, it is necessary to first ensure that all construction equipment meets the construction requirements, and that the equipment can operate safely by inspecting the working status of the construction equipment<sup>[3]</sup>. In addition, the inspection of construction materials should be strengthened and all construction materials entering the site must meet the standards. It is also necessary to stack them at designated locations, with proper classification to effectively prevent quality problems with the construction materials. Before construction, the construction site drawings should be checked again, the wiring work should be done based on the

drawings, the workload should be reviewed, and the construction time should be adjusted based on the weather.

## **4.2. Pipe jacking construction technology**

### **4.2.1. Muddy water propulsion method**

The muddy water propulsion method requires a cutterhead boring machine as the main construction machine. The construction personnel gradually advance by controlling the frontal soil pressure. In the construction, it is necessary to ensure the stability and balance of pressure, and adjust the circulating water pressure according to the specific situation. This propulsion method is conducive to ensuring the stability of groundwater pressure. In addition, construction will be carried out step by step to avoid interruptions in the process.

### **4.2.2. Earth pressure propulsion method**

The earth pressure propulsion method in pipe jacking construction is a relatively common construction method. It refers to a construction method that uses balanced pressure to advance after the mixture in the cutting chamber reaches a saturated state. In earth pressure propulsion construction, there is no need to use transportation equipment such as mud pumps, and propellers can be used directly. The low-cost equipment does not require mud treatment, which can improve the construction effect and economic benefits of the project. Generally, balanced tunnel boring machines are in single-blade or multi-blade mode, and are mainly used for pipe diameter advancement from 1,000 to 3,000 mm.

### **4.2.3. Mud-concentrated propulsion method**

This method uses secondary grouting as the main construction method, which can reduce the friction on the ground and improve the efficiency of pipe jacking construction. This construction method can effectively separate the gravel above and below the ground and transport these materials from the underground to the outside. At present, the mud-concentrated propulsion method is widely used. During construction, the excavation position of the construction pit is first determined, then concrete pipes are made, and multiple concrete pipes are assembled into a whole. Subsequently, the oil pump is used to jack up the construction to achieve pipeline connectivity. After pipe jacking construction, there is no need to disassemble the pipeline. Construction workers can inspect all aspects of the pipeline and make sure there are no abnormalities before proceeding with construction.

## **4.3. Jacking construction process**

### **4.3.1. Jacking construction inspection**

Before starting the pipe jacking, the status of the jacking equipment should be checked and a trial run should be conducted. Then it is necessary to dig out the mouth of the wall protection pipe and push the tool pipe into the soil layer. During the jacking construction, every 30 cm of construction work should be measured. If there is any deviation from the design, the deviation should be corrected in time. After the pipe enters the soil layer, during normal jacking, the amount of jacking needs to be increased to 100 cm each time, and at the same time, regular measurements and corrections are still required<sup>[4]</sup>. The allowable deviation of the elevation needs to be controlled within 3 mm. If it exceeds the allowable range, the deviation must be corrected in time.

### **4.3.2. Device installation**

For the design of the back wall, jacks are used as the main support structure. In order to ensure uniform stress on the back wall, steel plates can be laid on the wall panels<sup>[5]</sup>. Generally, the back wall needs to be kept perpendicular to the pipe jacking direction, and the vertical deviation range is controlled at about 0.1%. The

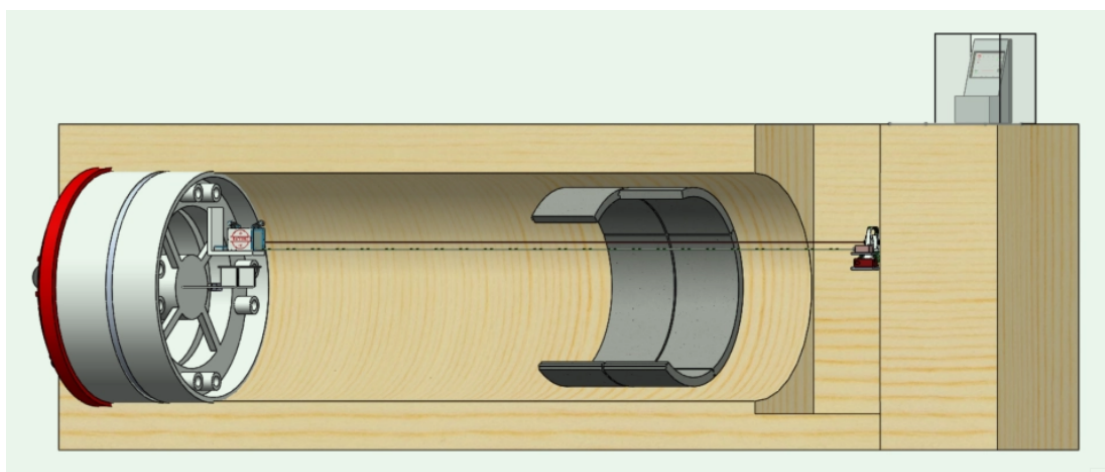
horizontal torsion error cannot exceed 0.1%. Next is the installation of the working well guide rail. The jacking slope and center line can be properly set based on the design requirements, and the safety and stability of the structure can be ensured by installing guide rails. At the same time, the installation location needs to comply with the slope and elevation requirements.

#### 4.3.3. Pipeline installation and construction

Before starting the pipe laying construction, the quality of the concrete pipe should be checked to avoid problems such as cracks and damage. At the same time, all pipes must have smooth walls <sup>[6]</sup>. The quality of the pipe mouth shall meet the construction standards, and the pipe shall be cleaned and lubricated. It is also necessary to check the lifting equipment of the pipe to make sure it meets the construction requirements before lowering the pipe. When lowering the pipe, after lowering the first section of the pipe, the bottom elevation and center of the pipe are measured to ensure that the position of the pipe pattern meets the construction requirements.

#### 4.3.4. Measurement and correction

The measurement work during pipe jacking construction has relatively high requirements for refinement, and the test results are directly related to the quality and efficiency of pipe jacking construction. It is also the main basis for deviation correction. Therefore, during pipe jacking construction, construction workers must make full use of laser levels and total stations for measurement. After the measurement is completed, they should perform deviation correction based on the measurement results and the direction of the deviation <sup>[7]</sup>. Generally, the pipe jacking should be measured once every 20 to 50 cm. When the construction process is normalized, the frequency of measurements can be reduced. In the measurement of the center line, plumb bobs can be hung on both sides of the working well and the pile body can be extended to the bottom. By comparing the position of the laser level with the plumb weight, the scale value of the center ruler is read, and the corresponding value is judged according to the specific test results <sup>[8]</sup>. If the laser coincides with the center line, it means that there is no deviation from the direction and thus meets the requirements. Otherwise, the deviation needs to be corrected. During the elevation test, the laser level is set at the position of the top iron, and the elevation measurement results are obtained by measuring the front-end pipe body. The last process is correcting the deviation. Combined with the actual measurement results of pipe jacking construction design, the measurement and correction are done properly. The guide joint should be set on the tool and the guide jack should be set. If the deviation exceeds 5 mm, it is necessary to correct the deviation in time to ensure the accuracy of the jacking direction. An automated correction and guidance system (**Figure 1**) can also be used to complete more precise correction work.



**Figure 1.** Automatic guidance system for catheter deviation correction

## **5. Pipe jacking construction technology and construction measures for municipal road drainage projects**

### **5.1. Strengthening pipe jacking inspection and control**

The distance measured by pipe jacking is generally no more than 150 m and is tested by a laser theodolite. Under the operation and guidance of professional personnel, the elevation and direction of pipe jacking are detected and controlled. During pipe jacking construction, it is easy to cause undesirable situations such as displacement of the starting point and the backsight point. In order to effectively prevent these problems, pipe jacking measurement and inspection must be strengthened. Routine inspections need to be carried out once a week. If the project is complex or the geological conditions are poor, the frequency of inspections needs to be increased appropriately <sup>[9]</sup>. If there is a large deviation between the inspection results and the design, the reasons for the deviation need to be analyzed and dealt with in a timely manner. After a section of pipe jacking construction is completed, the elevation and center of the pipe are inspected. The specific detection point settings should be determined based on the corresponding parts. Generally, one measurement point is set for one interface. If the position of the nozzle is misaligned, additional measurement points need to be appropriately added.

### **5.2. Strengthening road surface settlement detection**

During the pipe jacking construction of municipal road drainage projects, it is necessary to determine whether the specification requirements are met by measuring the level of the working well and calculating the settlement movement value. During the construction of the receiving well, the slope displacement of the well should be detected, and corresponding improvement measures should be taken based on the detection results to ensure the safety of the construction. During construction, it is necessary to adopt corresponding monitoring network devices and set corresponding reference points to meet the road settlement requirements. During pipe jacking construction, observations should be made at least once a day, and observation information should be recorded in a timely manner. After the construction is completed, continuous testing is required to determine the specific settlement situation, and the allowable settlement deformation is controlled within 20 mm.

### **5.3. Taking scientific management measures**

During the construction of municipal road drainage projects, before entering the hole for pipe jacking construction, the condition of the hole should be inspected first. A drainage system was also constructed to drain all water from the working well to facilitate subsequent construction work. At the same time, construction work is carried out strictly in accordance with the requirements of the construction drawings <sup>[10]</sup>. During excavation in the early stage of construction, it is necessary to ensure the suitability of the excavation and avoid over-excavation or under-excavation problems. In the event of an emergency, parameter adjustments need to be made in conjunction with approval requirements. During jacking, workers should work together to control the speed of jacking and the amount of slag produced, thereby creating a more stable and safe construction environment. At the same time, the control of jacking pressure and excavation surface pressure is strengthened to maintain a balanced development state.

## **6. Conclusion**

In summary, the pipe jacking construction technology of municipal road drainage projects is an important construction method in current urban municipal projects. Through pipe jacking construction method, it can

improve the excavation chaos of pipe network in traditional pipeline construction, improve the economic and social benefits of pipe jacking construction in drainage engineering, and avoid the impact on citizens' lives. However, it is necessary to consider common construction problems during construction, and perform prevention and control to prevent hidden construction hazards and ensure construction quality.

## Disclosure statement

The author declares no conflict of interest.

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