

EDITORIAL

## Construction Technology of Pipe Jacking Method through Underground Obstacles

Jiayong Han<sup>1,3</sup> Dongfeng Jia<sup>2</sup> Fushun Yan<sup>2</sup> Yue Zhao<sup>4\*</sup> Dong Liu<sup>1</sup> Qinghai Wang<sup>1</sup>

1. School of Civil Engineering, Shandong Jianzhu University, Jinan, Shandong, 250101, China

2. The Third Construction Co.,Ltd. of CTCE Group, Tianjin, 300163, China

3. Key Laboratory of Building Structural Retrofitting and Underground Space Engineering (Shandong Jianzhu University), Ministry of Education, Jinan, Shandong, 250101, China

4. Science and Technology Service Platform, Qilu University of Technology (Shandong Academy of Sciences), Jinan, Shandong 250000, China

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Due to the increase in the global urban population and the continuous improvement of requirements, urban infrastructure construction is developing rapidly. Various underground pipelines and channels are increasing and the demand is increasing. As a trenchless technology, pipe jacking construction technology has been widely used in pipeline laying and underpass construction, especially in complex urban environments and cross-river regions, which has great advantages<sup>[1]</sup>. However, the pipe jacking machine may be resisted by underground obstacles in the construction process due to various reasons, such as the

lack of reasonable planning of underground space development in the early stage, different structure forms of underground excavation support and foundation, complex geological conditions and etc. The underground obstacles include the foundation structures of existing buildings, support structures of underground excavation, abandoned structures, existing pipelines and solitary rocks. The pipe jacking machine crossing the stratum with obstacles will bring great risks, which will be a great challenge for the practice of pipe jacking engineering. The construction technology of pipe jacking through underground obstacles

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\*Corresponding Author:

Yue Zhao,

Science and Technology Service Platform, Qilu University of Technology (Shandong Academy of Sciences), Jinan, Shandong 250000, China;

Email: [zhaoy@sdas.org](mailto:zhaoy@sdas.org)

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still needs further investigation.

The development of mechanical equipment and construction method of pipe jacking method mainly draws on the application experience of the shield method in the early period. Common shield tunneling machines and pipe jacking machines are usually only applicable to strata with little change in mechanical properties and do not have the function to remove obstacles in strata. For a slurry-balanced shield machine, a small crusher is equipped to ensure the smooth excavation of the mud suction pump, which can break small stones. When obstacles, such as reinforced concrete piles, underground diaphragm walls, or large solitary stones, are encountered on the tunnel or pipeline line, common shield tunneling machines and pipe jacking machines cannot pass through directly. In this case, adjusting the line position to avoid obstacles and structures is an economical and safe method. When the line cannot avoid obstacles, treatments such as removing existing structures, pulling piles on the ground, and removing obstacles after digging shafts could be used to remove the obstacles in advance. Subsequently, the pipe jacking machine could be jacked through this region. With the continuous improvement of the shield tunneling machine and pipe jacking machine technology, the cutting performance of the shield tunneling machine and pipe jacking machine has been continuously improved. Cases of direct-cutting obstacles have appeared in the past decade, such as the Shenzhen North Ring Line, Shanghai Metro Line 10, Suzhou Metro Line 2, etc. [2]. The mentioned cases are all practices of the shield method directly cutting underground obstacles. However, the cases of pipe jacking method are rare. Direct cutting of reinforced concrete structure has great wear to the cutter head. A large number of studies have made beneficial improvements to the performance of the shield cutter head, mainly by improving the configuration and performance of different types of cutters. For a pipe jacking tunnel, its diameter is often smaller than a shield tunnel, it is less difficult to directly cut obstacles.

Among the types of underground obstacles, the anchor cable structure is the most difficult one to deal with. Anchor cable is a kind of anchorage technology, which is often used as the support structure of underground excavation with a pile or diaphragm wall. The anchor cable structure is composed of grout and steel strand, which has a high tensile strength of 1860 MPa. Therefore, if the pipe jacking machine cuts the anchor cable structure directly, the cutter head could be wound due to the high toughness of the steel strand, which could cause damage to the pipe

jacking machine. At present, the common crossing method is to remove the existing anchor cable structure and then perform the pipe jacking method. When the space requirement is satisfied, the anchor cable can be directly pulled out at one end. However, this method has two disadvantages: 1) When the pull-out force is insufficient, the anchor cable cannot be pulled out (in this case, the casing follow-up method can be used to reduce the friction resistance between the anchor cable and the ground); 2) Corrosion of anchor cable structure causes the anchor tendon to break. Therefore, the method of directly pulling out the anchor cable is often unable to complete the removal of the anchor cable structure. In addition, a rotary drilling rig can be used to drill and remove the anchor cables. The rotary drilling rig has a high torsion force. Through torsion and winding, the steel strand could be taken out of the ground. However, this method needs a large workspace and has a rotary drilling workload. In addition, the anchor cable structure can be broken manually by excavating the existing anchor cable area. However, in the process of excavation, the construction of excavation support structures is the most difficulty of this method. Because of the existence of a steel strand, the water stop system of the supporting structure can not be continuous, resulting in waterproofing failure. Based on this, combining the steel-sheet piles and jet grouting piles for waterproofing and supporting excavation methods for crossing the anchor-cable area is proposed [3]. Through the occlusion of steel sheet piles and high-pressure jet grouting piles, waterproofing can be ensured in the process of excavation construction. The mentioned methods have been successfully applied in many case histories. When the surrounding environment is complex, the surrounding strata are often reinforced by grouting.

To sum up, some solutions to pipe jacking through different underground obstacles have been proposed. However, there is still great room for further improvement. Especially for the case of pipe jacking through the stratum of anchor cable structure, the construction technology is still complicated for professional persons. Therefore, more efforts are required to improve the mechanical properties of pipe jacking machines and study the obstacle removal methods.

### **Conflict of Interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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