Application of MJS Construction Method in Reinforcement Construction of Existing Box Culverts Under Comprehensive Pipe Gallery

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Abstract. The MJS construction method can reduce the impact on the environment and has the advantages of large pile diameter and good pile body quality. In recent years, it has been widely applied in the field of engineering reinforcement. This article takes the MJS reinforcement project of a comprehensive pipe gallery project in Xi'an as the research object, and uses a combination of on-site monitoring and numerical simulation to study the reinforcement effect of the MJS method. The research results indicate that after using the MJS construction method to reinforce the box culvert, the elastic modulus of the soil layer around the existing box culvert has been improved to a certain extent, avoiding significant deformation of the box culvert and the surrounding soil. After using MJS to comprehensively reinforce the existing box culvert, the deformation size of the structure meets the control standard value to ensure the safety of the existing box culvert.

Keywords：Integrated pipeline corridor；Box culvert；MJS Method.

1. Introduction

With the rapid development of China's economy, the development and utilization of underground space in China is gradually shifting towards a comprehensive and deep level, and new tunnels are facing more and more complex working conditions of passing through buildings. The importance of ensuring the safety of existing buildings through various reinforcement methods is also increasingly prominent. The MJS construction method is based on conventional high-pressure jet grouting technology, utilizing special porous pipes and front generation mechanisms to achieve real-time monitoring of forced mud discharge and ground pressure in the well. By adjusting the amount of forced mud discharge, the ground pressure is controlled, greatly reducing the impact on the environment, and also making the pile diameter large and the quality of the pile body good. In recent years, it has been widely used for engineering reinforcement.

Kong Weiyang et al[1] analyzed and studied the effect of MJS method pile formation, relying on the application example of MJS method pile soil reinforcement of a city rail transit line 2 in Guangdong. Chu Shuo et al[2] took the Wuxi Metro Line 3 Wangzhuang Road Station project as an example to analyse the specific application of the MJS method and put forward the main considerations in the application of this technology. Xu Feng et al[3] have analysed the lateral and vertical displacements of MJS piles on adjacent pile foundations on the basis of a foundation project for a high-speed railway station in Hai'an. The results of the study showed that the MJS piles were effective in influencing the pile foundations of the adjacent HSR station building during the excavation of the foundation pit. Wang Huaidong et al[4] conducted field experiments on the influence of MJS piles in the piling works of high-speed railway stations, and the results showed that MJS piles could better inhibit the pile deformation of adjacent high-speed railway stations due to pit excavation.

This paper relies on an excavation of a pipe corridor under the existing box culvert MJS method pile reinforcement application example This paper uses on-site monitoring and numerical simulation, the MJS method pile reinforcement effect of the study, for the construction of similar projects to provide a reference basis, and the promotion of similar projects has some guidance significance.

2. Project overview and monitoring programme

2.1 Project Overview

The project is a comprehensive pipeline corridor project in Xi'an, which starts from the West Third Ring Road in the west and ends at the north of Zhangba Road in the east; The starting pile is K0+100 and the ending pile is K2+720, with a total length of 2.62km. The integrated pipe corridor consists of natural gas compartment, thermal compartment, integrated compartment and electric compartment, with a total width of about 13.60/13.90m and a total height of about 3.85/4.25m. The main body of the pipe corridor is a reinforced concrete structure, with an average overburden depth of about 3.5m at the top of the integrated pipe corridor and a maximum overburden depth of about 12.5m in the local underpass section. The net plan size of the underpass box culvert is 2*7.5m, with a net height of 5.7m and a total plan width of 17m; the depth of overburden at the top of the box culvert is about 2.5m. Bottom of box culvert buried approx. 10m. The specific location is shown in Figure 1.

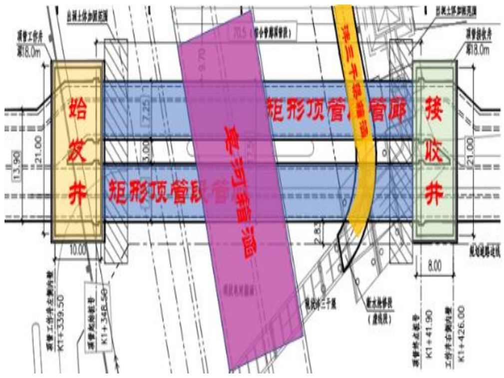


Fig.1 Schematic plan

2.2 Monitoring programme

To ensure the safety of surface buildings and pedestrians during pipe jacking crossings, automated data acquisition instruments are used to monitor the effects of pipe jacking crossings on soil deformation. The test content is the vertical displacement of the ground surface. The specific monitoring point arrangement is shown in Figure 2.

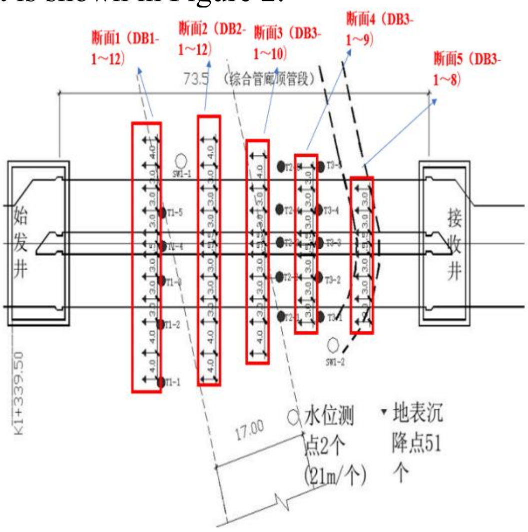


Fig.2 Plan of measurement points

3. Analysis of monitoring results

To illustrate the safety of the MJS method for rectangular pipe jacking construction corridors after reinforcement of the soil beneath existing box culverts, data from five sets of monitoring sections were collected as a means of analysing the impact of pipe jacking construction on surface settlement. At the beginning of the construction of the pipe jacking, the milepost number is K+349. The monitoring area is from milepost K+361.67 to K+422, and the monitoring period is from 6.21 to 9.26.

Real-time settlement profiles for the settlement monitoring points are shown in Figure 3-8. From the monitoring data, it can be seen that as the construction progressed, different degrees of uplift occurred at the measurement points of each monitoring section, but the overall trend was more or less the same in the last week of monitoring when the surface settlement reached its peak, with extreme values of 17.89mm, 10.34mm, 12.95mm, 15.58mm and 30.75mm for the five measurement lines respectively; The maximum values are all located approximately at the central axis of the tunnel, in line with the general settlement pattern and within a safe and manageable range.

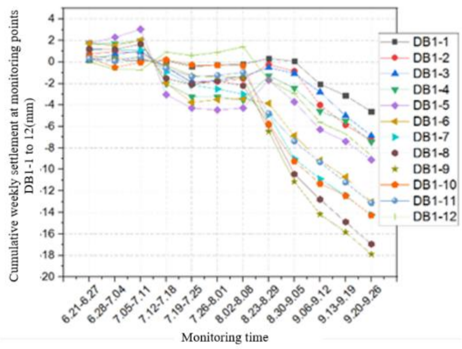


Fig.3 Cumulative settlement at monitoring points DB1-1 to 12

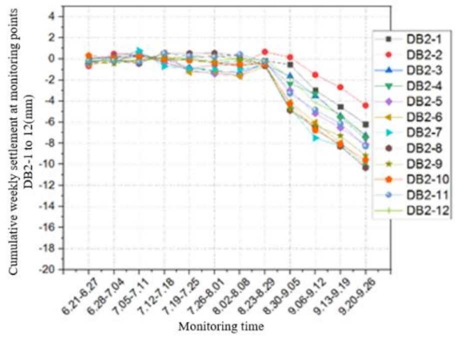


Fig.4 Cumulative settlement at monitoring points DB2-1 to 12

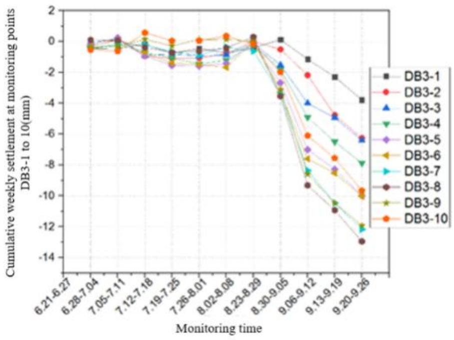


Fig.5 Cumulative settlement at monitoring points DB3-1 to 10

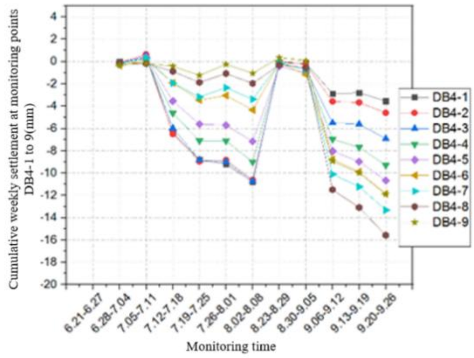


Fig.6 Cumulative settlement at monitoring points DB4-1 to 9

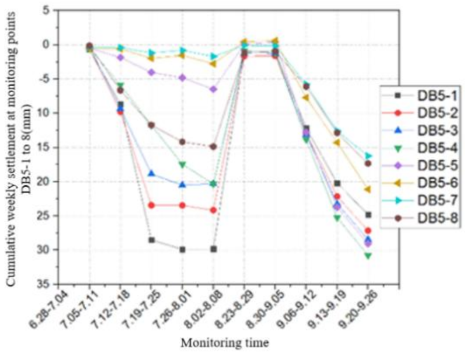
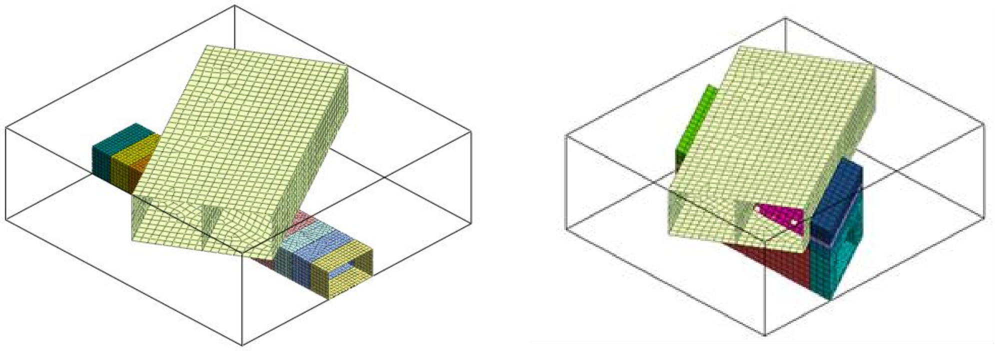


Fig.7 Cumulative settlement at monitoring points DB5-1 to 8

4. Numerical simulation comparison of MJS reinforcement effects

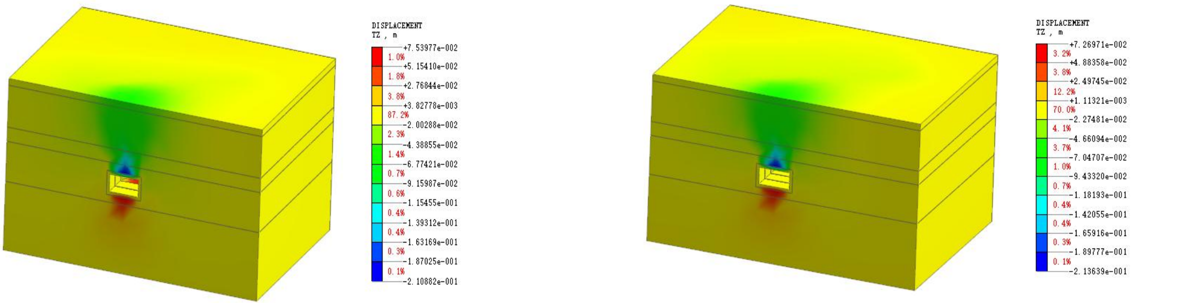
In order to further study the degree of influence of the horizontal MJS method on the stability of the existing box culvert during the pipe jacking construction, the reinforcement effect of the horizontal MJS method during the pipe jacking construction of the pipe corridor was analysed and compared by establishing two working conditions without and with reinforcement measures. The model is shown in Figure 8 below.



(a) Pipe corridor under existing box culvert **(b) Reinforcement of the soil around the pipe gallery**

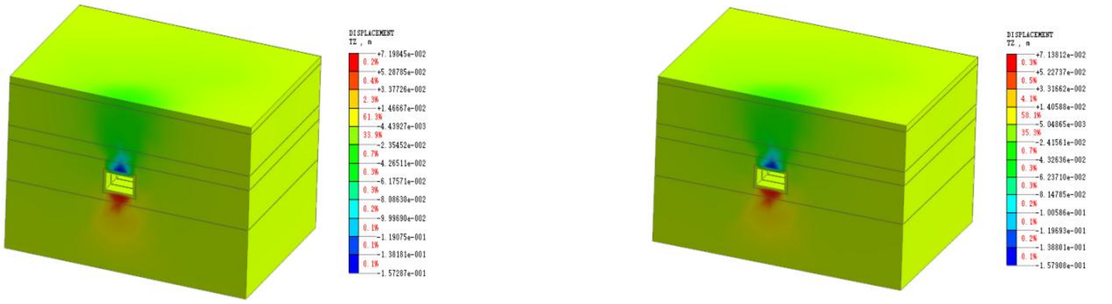
Fig.8 Calculation mode

The results of the numerical simulations are shown in Figures 9 and 10 below, from which it can be seen that before the reinforcement of the existing box culvert, the maximum settlement of the soil layer occurs below the tunnel, with a value of 21.3 mm, and the maximum uplift of the soil layer occurs below the tunnel, with a value of 7.71 mm. The settlement and uplift displacement of the soil were reduced by 25.7% and 8% respectively after the use of the MJS method of reinforcement. This indicates that the settlement of the soil layer in the existing box culvert was reduced after the use of the MJS method. After the reinforcement of the existing box culvert area, the vertical displacement of the reinforced ground was analysed in stages of every 10m of excavation. Figure 10 shows a cloud of the vertical displacement of the surrounding soil during the excavation of the tunnel. From the displacement clouds, it can be seen that the vertical displacement of the soil above the tunnel gradually increases and spreads to both sides as the shield construction progresses: the soil below the tunnel will gradually decrease in elevation value as the distance increases. The displacement clouds of the reinforced soil follow the same trend as those of the unreinforced soil, but there is a more pronounced uplift of the ground surface above the reinforced area.



(a) 10m of the excavation face of the corridor through the existing box culvert **(b) 20m of the excavated surface of the pipe corridor through the existing box culvert**

Fig.9 Cloud of vertical soil displacement before reinforcement



(a) 10m of the excavation face of the corridor through the existing box culvert **(b) 20m of the excavation face of the corridor through the existing box culvert**

Fig.10 Cloud of vertical soil displacement after consolidation

5. Conclusion

(1) After adopting the MJS method to strengthen the box culvert, the elastic modulus of the soil around the existing box culvert is improved to a certain extent to avoid large deformation of the box culvert and the surrounding soil. The settlement of the top plate of the box culvert is reduced by 38.31%; the settlement of the bottom plate is reduced by 42.44%; the horizontal displacement of the web plate is reduced by 68.28%. It shows that the deformation size of the structure meets the control standard value after the MJS comprehensive reinforcement of the existing box culvert when the new pipe corridor underpasses the existing box culvert, which ensures the safety of the existing box culvert to a large extent.

(2) According to the ground settlement and horizontal displacement information observed by the actual measurement, the relationship between the two is closer when compared with the numerical simulation results. The results show that the model constructed has good accuracy and scientificity, which is a good guiding significance for similar projects.

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