

Reinforcing the Bridges in Tunnel Excavation Region by Using a Method Combining Jacking Superstructure and Grouting Substructure

Bao Jin^{1, 2, a}, Yang Liu^{1, b}

¹School of Transportation Science and Engineering, Harbin Institute of Technology, Harbin, China, 150090

²Jinan Urban Construction Group Co., Ltd, Jinan, China, 250000

^ajin-_bao@163.com, ^bly7628@hit.edu.cn

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Abstract It is crucial to alleviate the effect of construction of underground transportation on the safety of the bridges in tunnel excavation region since it is inevitable for the tunnel to go across the city viaduct. To solve above problem, a technique of bridge reinforcement was proposed, which combines the jacking superstructure of bridges and grouting substructure. With this technique, the uneven settlement of the bridge foundation could be controlled as well as the change of the upper structure of bridges could be limited in a reasonable interval. Finally, the effectiveness of proposed method is demonstrated by reinforcing a real bridge in the region of subway construction in Guangzhou, China.

1. Introduction

It is impossible to avoid the effect of the construction of underground transportation on the safety of bridges located in the same road network since the city subway network are always accordance with the road network. Especially, the effect of subway tunnel excavation on bridges could not be ignored. The reason is that the subway tunnel excavation construction causes the disturbance of surrounding soils, which may reduce the ability of resisting load of the soil layer [1,2]. Meanwhile, the soil disturbance causes the loss of groundwater in a certain amount, which is the direct reason for uneven settlement of bridge foundation [3,4]. Therefore, it is important to alleviate uneven settlement of bridge foundation caused by the construction of subway and to ensure the ability of resisting load.

This paper proposed a method for reinforcing the bridge foundation by combining the jacking superstructure and grouting substructure of bridge. The basic idea of this method is that, on one hand, the change of the upper structure of bridge could be controlled in a safety limit, and, on the other hand, the uneven settlement of bridge foundation could be alleviated in a safety interval. Need to point out that the proposed technique only can be applied to the bridges with continuous girder or the simply supported beam, but not to continuous rigid frame bridges.

2. Bridge foundation reinforcement by using the combination between jacking superstructure and grouting substructure

2.1 Introduction of Bridge foundation reinforcement by using the combination between jacking superstructure and grouting substructure

The procedure of proposed method is described as follows: start → tunnel excavation → close the working platform temporarily → jacking the superstructure of bridges → drill and set up grouting pipe at the working face → drill and set up grouting pipe for side work face → grouting

the sleeve valve tube → soil consolidation → tunnel excavation → construction monitoring → repeating grouting.....→ the tunnel goes through the bridge foundation → construction monitoring → sealing grouting pipe → end

2.2 Implement of Bridge foundation reinforcement by using the combination between jacking superstructure and grouting substructure

2.2.1 Implement of jacking superstructure of bridge

(i) Set up the scaffold platform

(ii) Placement of Jack

When the superstructure of bridges are jacked, different types of jack could be selected according to the actual situation between the pier and girder, e.g., two types of jack are popular, i.e. 320 tons and 180 tons of ultra-thin jacks.

(iii) Jacking the superstructure of bridge

The success or failure of jacking directly influence the safety of the bridge, so it is necessary to take some effective measures to ensure that the bridge jacking would be completed in the shortest time. Initial lifting force of jack should be about 50% of the controlling values, and then the load will be implemented by additional 5% for each time. When the jacking goes to the design position, replacing the bolt on the support by steel plates and unloading slow.

(iv) Construction monitoring

Here, the displacement of girder should be monitored during the process of jacking. The sensors could be fixed at four standpoints on the top of pier.

2.2.2 Implement of grouting substructure of bridge

(i) Drilling

The DTH drill can be applied and the drill could be selected according to the diameter of the hole. After drilling, the high quality thin slurry supporting could be utilized. In case for the collapse of the hole, drive pipe could be applied to reinforce the structure of hole. When the casting materials are injected into the holes, the drive pipe should be taken out.

(ii) Set up sleeve valve tube, pour casting materials

When the design depth is obtained, casting materials (clay slurry) and grouting scope of material will be poured into the hole in order to prevent sleeve valve grouting pipe to be distorted or damaged. According to the grouting requirements, type B grouting pipe should be poured into grouting part.

(iii) Solidification

The grouting need to wait until the slurry near orifice is solidified. The time for solidification should be controlled about three days.

(iv) Ring opening grouting

In the early period of the grouting stage, the slurry (or water) is applied to increased pressure. During the process of pressuring, the open loop would be realized if the pressure dropping dramatically or the pulps increase rapidly. To ensure the safety of grouting, the right order should be obeyed.

(v) Construction monitoring

During the grouting process, the effect of grouting pressure may cause the ground to go up, which may make damage the surface of concrete road or tunnel primary support. Therefore, the settlement of bridge foundation shall be monitored in order to guide the construction safety.

3. Practical application of proposed method

3.1 Introduction of practical example

The proposed method is applied to reinforce the bridges in the tunnel excavation region. This project is located at the intersection between west road and sai wan road, Guangzhou, China. The inner loop viaduct is up on the station, the left line consists of $3 \times 22\text{m} + 24\text{m} + 3 \times 22\text{m}$ continuous rigid frame bridge and $26\text{ m} + 40\text{ m} + 26\text{ m}$ prestressed concrete continuous girder, and the right line consists of $3 \times 22\text{m} + 3 \times 24\text{m}$ continuous rigid frame and $26\text{ m} + 40\text{ m} + 26\text{ m}$ prestressed concrete continuous girder. The inner loop viaduct takes use of $\Phi 1200$, $\Phi 1500$, $\Phi 1800$ of bored piles, the pile foundations are end-bearing pile and friction pile. During the construction process, 25 foundation (XJ25) and 34 foundation (XJ34) occurs larger settlement, as shown in Fig.1.

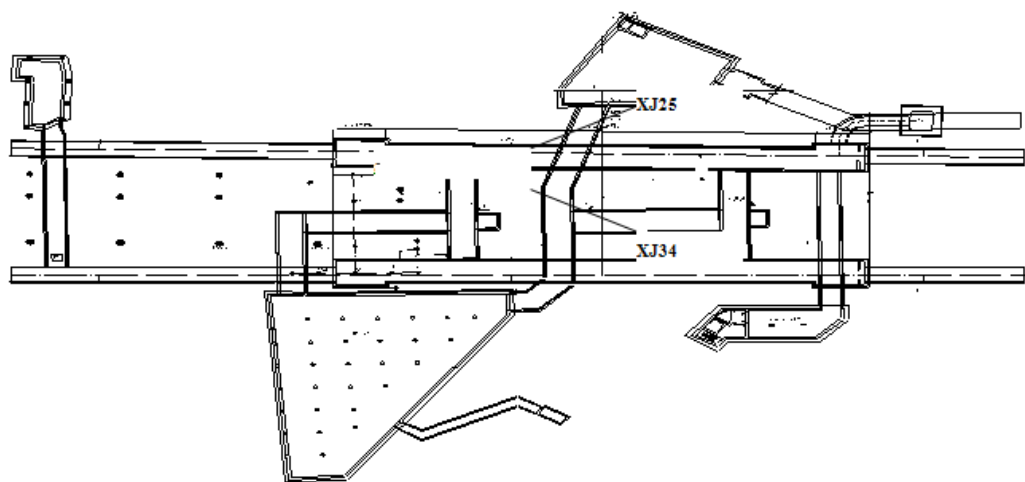
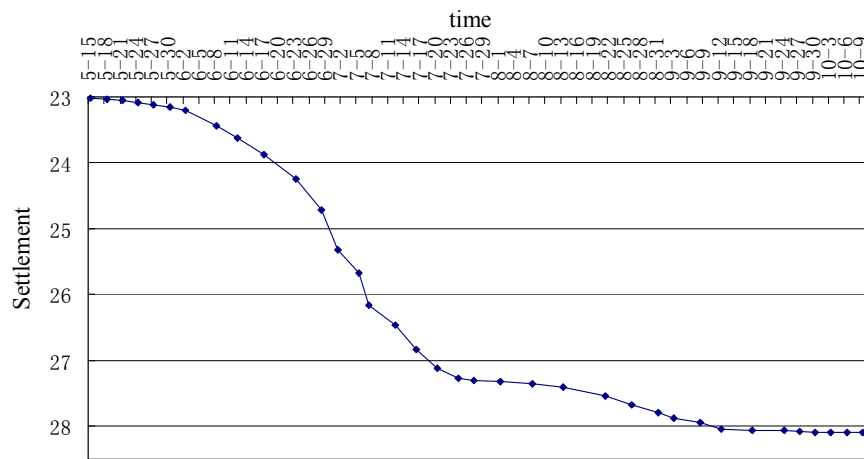


Figure 1 Tunnel and pile foundation position schemes

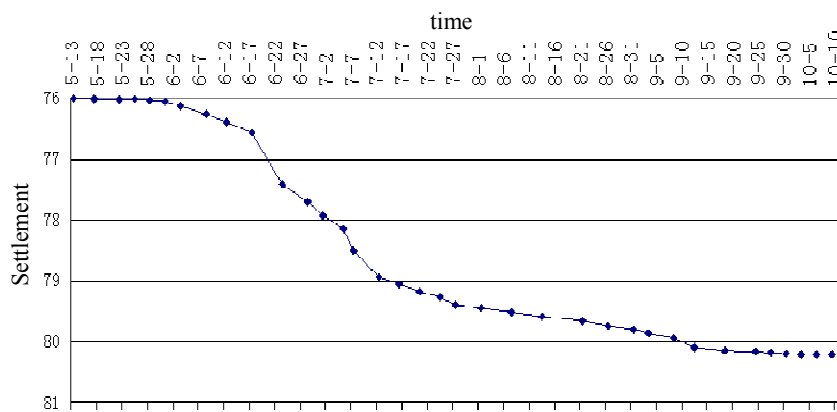
3.2 Application of proposed method

The No.25 and No.34 bridge foundation were reinforced by using the proposed method. Each bridge foundation was jacked twice, and the process of settlement of foundation is shown in Fig. 2.

According to the design code of bridge of China [5], the theoretical settlement of No. 25 and No. 34 pier go to 27.74 mm and 80.16 mm respectively. Comparing with the results in Fig.2, both settlements of two piers after reinforcement by using proposed method belong to the allowed interval. Therefore, the effectiveness of proposed method was verified.



(a) XJ25 foundation jacking and grouting



(b) XJ34 foundation jacking and grouting

Figure 2 Settlement of bridge foundation during construction

4. Conclusion

A method combining the jacking and grouting was proposed to reinforce the foundation of bridges that are located in the tunnel excavation region. The basic idea of proposed method is to solve the reinforcement of bridge foundation caused by tunnel excavation in both sides, i.e., jacking the superstructure and grouting the substructure of bridges. With the proposed method, the uneven settlement of the bridge foundation could be controlled as well as the change of the upper structure of bridges could be limited in a reasonable interval. The proposed method account on the advantages of both jacking and grouting technology, and this method overcome the disadvantages of traditional method, such as the complex procedure of implementing, long cycle of construction, damage of surroundings and traffic interruption. According to rough statistic, each blade foundation reinforcement can save construction costs 100,000 ¥.

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