ABSTRACT: The paper describes the impact on the existing subway tunnel when using different methods to excavate the cable tunnel which is upon the subway tunnel. In this paper we use three-dimensional finite element modeling method to establish Soil - Cable Tunnel - Subway Tunnel model. Using numerical simulation method to analyze three different excavation working conditions. Then compared with each other.

1 INSTRUCTION

The cable tunnel, 220kv, of Suzhou bamboo-garden segment and upon Line 1 subway tunnel, is the double-line shield tunnel. The shield diameter is 6m, the gap between line 6m and subway roof buried in 9.0m depth. The subway tunnel lining segment is 0.35m thickness, 2m length, and used of C50 concrete. The cable tunnel is double-line, the roof buried in 1m depth, and the tunnel board is 0.3m thickness, 4m width and 4m height. The pit bottom is strengthened by string pile and 3.5m thickness at the bottom. The 24 hour monitoring of subway tunnel is adopted, and the whole system includes TCA automatic instrument for the whole station, prism, communication cable and power cable, computer and unique software, and the observation point, which is set in every 4m along the tunnel.

2 ESTABLISHING THE FINITE MODEL

Firstly, the existing engineering data is simulated, and we will compare the simulation data with the subway deformation trend measured on-site to verify the correctness of the simulation method. By using the finite element software MIDAS/GTS, the subway tunnel-soil body-cable tunnel, the three-dimension finite model is established. The soil body is 60m length, 40m width, 25m depth. At the same time, the cable tunnel, the support structure and the subway tunnel are built. The geometric model sees figure 1.

The tunnel segment is simplified for plate-element, the support structure of the foundation pit is equivalent to plate-element, cable tunnel use the solid-element, and the condition on boundary of the soil body is the normal constraint. The gravity load is added, the soil body uses the Kulun model, the concrete is regarded as elastic, and pre-establish the necessary soil body before excavation. The "activate" and "passivation" is used to simulate the excavation process during the engineering period. The finite element model will be adjusted if the big difference with measured engineering trend happened. Due to the round section of the subway tunnel, the hexahedral is difficult to deal with arc web-mesh when dividing the web-mesh, so we use the high-order tetrahedral. The element is 2m and the subway surrounding carry out the seed encryption. The divided web-mesh seen figure 2.
The accomplishment method: 1. Active the initial soil body element and keep the stress balance, the displacement is cleared as zero. 2. Active support structure and pit-bottom’s stirring pile elements. 3. Passivate the excavation soil body element. 4. Active pre-done cable tunnel elements and the backfill soil body elements.

By the calculation of the finite element software MIDAS/GTS, the deformation cloud picture of subway tunnel is obtained as figure 3.

In practice, the soil body is not evenly distributed in the nature, the nature of the soil body has certain differences with the geological exploration report, and the field measurement data also has certain errors, which lead to the differences between the simulation data on the original work condition and actual testing data. If the simulation data is complies with actual measurement data in general, we can adopt this method to carry out the analysis of the latter problems. Through the simulation analysis of the original condition, we find that the maximum displacement of the subway tunnel is generated when the foundation pit is fully excavated, so this effect of this step on the subway tunnel will be studied in latter.

3 STUDY ON THE EXCAVATION METHOD

3.1 Normal excavation method

Firstly, the simulation of the normal excavation without strengthen is carried out and the result will be as the comparison data for the latter research. The normal excavation indicates that the soil body of the cable tunnel foundation pit is excavated from top to bottom and the excavation steps is simplified to dig the soil body of the power cable tunnel foundation pit at one-time in the research, thus the displacement of the subway tunnel is obtained. From the 2.3-2 cloud picture, the displacement of the subway tunnel in the normal excavation method without reinforcement, the max displacement 10.02mm is found right under the excavated foundation pit. According to the shield technology specification of the metro tunnel engineering construction and the requirement of the Shanghai metro company limited. The displacement of the shield subway tunnel in the operation stage can’t exceed 5mm, thus the normal excavation without reinforcement can’t meet the requirement, and so we need to change the excavation method or soil body reinforcement treatment.

3.2 New excavation method 1

The soil body is divided into D1, D2, D3, D4, and D5, five parts, shown in figure 5.

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The first step is to dig D1, D3, D5, three parts of soil body and the displacement of the subway tunnel and then, to dig D2, D4, the final displacement of the subway tunnel is obtained after excavating the whole segment of the soil body. The deformation cloud picture of subway tunnel is obtained as figure 6.

![Figure 6. New excavation method 1 cloud picture.](image)

From the above data, it can be seen that the maximum displacement of the subway tunnel is 4.8mm when the excavation method is changed, and the changed method can significantly reduce the displacement under fully excavation of the soil body.

### 3.3 New excavation method 2

Excavate along the longitudinal of the foundation pit, from one side to the other side, from 1 to 6. The excavation width shall be controlled in 2m till the end of the segment as is shown in figure 7.

![Figure 7. New excavation method 2.](image)

In MIDAS/GTS, the geometric model is built and the soil body excavated is divided into five parts. By calculation and analysis, the displacement of the metro tunnel for last step of excavation is obtained in figure 8.

![Figure 8. Finite element model of slab soil foundation.](image)

### 4 CONCLUSION

From the above chart, two kinds of methods can reduce the displacement of the subway tunnel, and the comparison shows the second method is less influence of subway tunnel when carrying out the cable tunnel excavation. Furthermore, the second method has less influence on the surrounding soil body. Thus, the second method is better than the first method.

### REFERENCES


