

Available online at [www.sciencedirect.com](http://www.sciencedirect.com)**SciVerse ScienceDirect**

Procedia Earth and Planetary Science 5 (2012) 150 – 154

---

---

**Procedia**  
Earth and Planetary Science

---

---

2012 International Conference on Structural Computation and Geotechnical Mechanics

## Numerical Analysis of the Influence of Isolation Piles in Metro Tunnel Construction of Adjacent Buildings

Aijun YAO<sup>a</sup>, Xuejia YANG<sup>a</sup>, Lei DONG<sup>b</sup>, a\*<sup>a</sup>*Institute of Geotechnical and Underground Engineering, Beijing University of Technology, Beijing 100124, China*<sup>b</sup>*Avic Geotechnical Engineering Institute Co., Ltd., Beijing 100098, China*

---

### Abstract

The metro running intervals with more and more existing constructions put an inevitable influence on the existing construction foundation. In order to control the impact to certain limits, it is necessary to adopt effective technical measures before construction. This thesis analyzes the effect of isolation piles in controlling building deformation during the tunnel excavation by using the finite difference software FLAC<sup>3D</sup>, which takes Beijing subway line eight as an example and the construction conditions are divided into no reinforcement measures and applied isolated piles. By the contrast analysis, isolation piles can effectively control the building deformation through stress isolation and building deformation can be accord with requirement of standard, then to ensure the safe use of the building. In addition, this thesis can give references for the same kind of tunnelling construction in the future.

© 2011 Published by Elsevier Ltd. Selection and/or peer-review under responsibility of Society for Resources, Environment and Engineering. Open access under [CC BY-NC-ND license](https://creativecommons.org/licenses/by-nc-nd/4.0/).

*Keywords:* isolation pile; shielding tunnel; side-crossing; deformation forecast; Numerical simulations

---

### 1. Introduction

With the rapid development of China's urban rail transportation and constant encryption of rail network, there will be more and more existing constructions surrounded by newly built rail. Therefore the effect to the adjacent buildings is inevitable and hard to ignore. Securing the existing constructions' safety and controlling the land subsidence are needed to be solved urgently.

In order to control the deformation and inter-influence of adjacent buildings, isolation piles become a very effective method. In Beijing and Shanghai, isolation piles have been used in real constructions. It can

---

\* Corresponding author. Tel.: +86-10-67396357

E-mail address: [yaj@bjut.edu.cn](mailto:yaj@bjut.edu.cn), [xjyelite@126.com](mailto:xjyelite@126.com).



#### 4. Project risk and coping measure

Because the plan-to-built left line through the formation are mainly silty clay and silty sand, the right line through the formation are silty sand and gravel. The self-stability of the ground soil is poor and the soil can not form a natural arch, construction process is subject to collapse. Because there exists small radius curve in the shield tunnel lines, the construction difficulty is huge. The adjacent structure is a public building and the smallest clearance between the building and the tunnel structure is only 2.2 m. Therefore, tunnel excavation leads to the ground displacement and relaxation inevitably, and furthermore the deformation and safe use of the building are bound to be impacted.

In order to control the uneven settlement of the building, isolation piles can be applied between tunnel structure and the existing building, which through the stress isolation to reduce ground loss and consolidation settlement after the soil disturbance, then to reduce the influence of the building foundation settlement caused by the tunnel excavation. Isolation piles are taken as the coping measure with a diameter of 800 mm, the pile length of 25 m.

#### 5. Numerical simulations

In this paper, the finite difference software FLAC<sup>3D</sup> is used in calculation, which considers the impact of tunnel excavation process to analyze the time-space effect problem of surface movement caused by construction process, considers the tunneling method of dynamic construction process and the role of soil reinforcement by, which also takes into account the interaction between the lining and soil [3-5].

##### 5.1. Calculation model and boundary conditions

According to the project design conditions, the computational domain is defined as follows: on to the ground, down to 30 m below the bottom of the tunnel, horizontal to 90m on each side of center line, along with the tunnel axis of 200 m.

The upper boundary of calculation model is the ground, which is free boundary, the lower boundary is constraint boundary, and the lateral boundary of the model is unidirectional boundary.

##### 5.2. Loads and strength criteria

Permanent loads are mainly considered in simulation process, including the dead weight of building, tunnel structures, isolated piles and the stratum. In the simulation, the building dead weight simplified to even distribution vertical load, which are applied according to the depth of the building foundation.

Mohr-Coulomb elastic-plastic constitutive model is applied for soil mass and large strain deformation is adopted as deformation mode; elastic constitutive model is applied for shield tunnel segment. Isolated pile uses pile element and shield tunnel uses shell solid element. Parameter value of each soil layer in the simulation process is obtained through the geotechnical investigation report.

##### 5.3. Simulation program and the analysis of results

Shield construction is the main construction method in this section. Right line of the bidirectional tunnel goes first, leaving the left line behind. With a view to analyzing the effect of shielding driving process to the foundation deformation of the adjacent buildings, the numerical simulation is divided into two kinds of construction conditions: Condition 1 does not apply any reinforcement measures; condition 2 applies the isolated piles between the buildings and tunnel structure, shown in Figure 2.

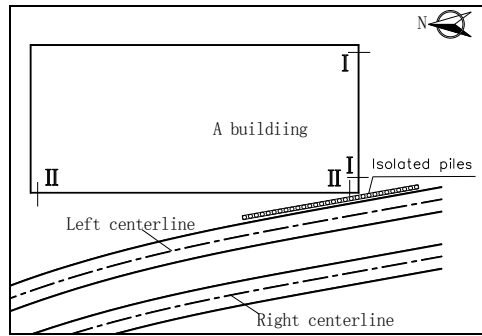


Fig. 2. Plane sketch of location among tunnels, building and isolated piles

The following conclusions could be drawn through analysis:

(1) After the tunnel excavation, the surface transverse subsidence curve presents the distribution of Peck curve, the largest settlement is 55mm in the center top of the two centerlines, shown in Figure 3.

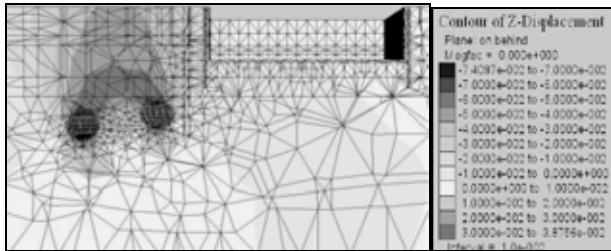


Fig. 3. Horizontal surface settlement curve under condition 1

(2) After the shield tunnel transfixion, the largest settlement of the building foundation is about 25mm in the southwest corner of the building.

(3)The shield tunnel goes through the neighborhood from the southwest side of the building foundation, which leads to the southwest side of a larger settlement, to gradually decrease to the northeast.

5.4. Reinforcement effect analysis

As shown in Figure 4, the largest settlement amount at the south edge of the building foundation (coordinates 5m to 42m range) is 15mm under condition 1; isolated piles play the role in controlling the foundation deformation in the coordinates range from 0m to 10m under condition 2.

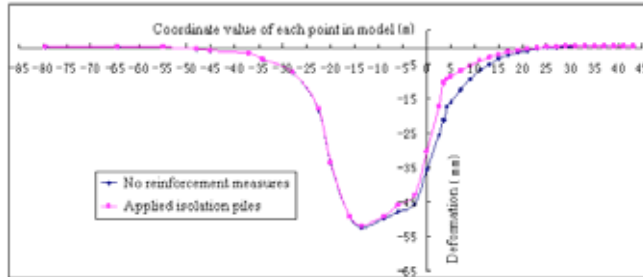


Fig. 4. I - I profile settlement curve of the south side of the foundation

As shown in Figure 5, the largest settlement amount at the west edge of the building foundation (coordinate -43m to -90m range) is 25mm under condition 1; isolated piles are applied in the coordinate range from -35m to -60m under condition 2, the largest settlement of the foundation is expected to 10mm, the role of controlling deformation is evident.

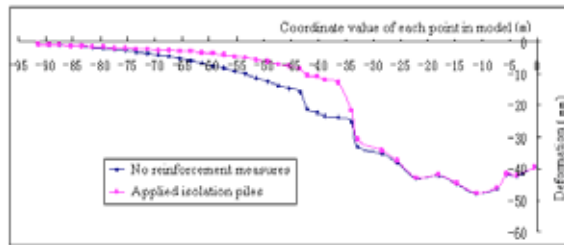


Fig. 5. II-II profile settlement curve of the west side of the foundation

## 6. Conclusion

Through research and analysis, it shows that there is effective effect to the isolation piles to control building deformation through reasonable design and strict construction conditions. Isolation piles play a role in isolating stress, which can reduce stratum displacement and control the building deformation and settlement caused by the tunnel excavation, then to ensure that the building deformation can be accord with the requirement of standard and assure the safe use of the building as well as tunnel normal construction.

In addition, the piles themselves are close to the metro, therefore the isolation piles section should be protected according to metro protection principle. Pit reinforcement is used in the isolation construction section in order to effectively block the effect of pile construction on the subway.

## Acknowledgements

Thanks to the Natural Science Foundation Project 50978007 and Beijing Municipal Education Commission Science and Technology Program KM200910005012.

## References

- [1] Yao Haibo, Wang Mengshu, Zhang Dingli et al. Mechanism of a drift-pile system and analysis of its horizontal displacement [J]. China Civil Engineering Journal 2006, 39(4): 105 - 109. (in Chinese)
- [2] Yao Aijun, Xiang Ruide, Heng Chaoyang. Dynamic response of the foundation deformation of buildings nearby the subway excavation [J]. Chinese Journal of Underground Space and Engineering, 2007, 3 (6): 157421578. (in Chinese)
- [3] Wei Gang. Prediction of ground deformation induced by shield tunneling construction [J]. Chinese Journal of Rock Mechanics and Engineering, 2009, 28(2): 418–424.(in Chinese)
- [4] Jia Xitao, Analysis on Application of Isolation Piles in Construction of Mined Tunnels Underneath Existing Buildings [J]. Tunnel Construction, 2006, 26( 1 ) : 25~ 26. (in Chinese)
- [5] Fei Wei, Application of isolation piles to deformation control of deep foundation pits close to buildings with shallow foundation [J]. Chinese Journal of Geotechnical Engineering, 2010,32(7): 265~270(in Chinese)