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Analysis of influence of excavation of small clear distance foundation pit on adjacent viaduct pile foundation

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Abstract: *Taking the Wuxi-Taicang Expressway Huishan Xincheng Tunnel underpassing the Wuxi Metro Line 1 viaduct (between Yanqiao Station and Xibei Canal Station) as an engineering example, the influence of tunnel foundation pit excavation on adjacent subway elevated is studied. Based on the Moore-Coulomb constitutive model, a three-dimensional finite element model was established by the combination of entity-structure composite elements, combined with elastic theory calculations and measured data of similar projects, and the influence of tunnel foundation pit construction on the surrounding soil and adjacent elevated bridge deformation was analyzed. Combining the deformation of the two, the corresponding viaduct protection measures and foundation pit support schemes are proposed, and the following conclusions are obtained: 1) The maximum horizontal displacement of the viaduct is 2.45mm, the maximum vertical displacement is 2.83mm, and the foundation pit retaining piles are obtained through numerical calculations. The maximum horizontal displacement is 5.43mm, and the maximum vertical displacement is 7.00mm, all of which have passed the verification and meet the requirements of the specification. 2) Comparing the displacement data of the retaining pile obtained by the numerical simulation with the calculation data of the traditional elastic method and the actual monitoring data of a certain project, the displacement laws of the three are consistent. The displacement value of the pile bottom is relatively small. 3) When the distance between the pile foundation and the foundation pit of the viaduct is relatively close, the supporting form of row piles + internal support is used with local soil reinforcement, which has a large foundation pit supporting rigidity and has a good effect on the protection of important structures.*

Keywords: *excavation of small clear distance foundation pit; viaduct pile foundation; numerical simulation; risk assessment; pile displacement; supporting structure; tunnel*

1. Introduction

With the development and utilization of urban underground space, many cities have built urban underpass tunnels to alleviate heavy traffic. The urban underpass tunnel adopts the open-cut method of construction, and the tunnel underpass process will likely encounter many risk sources, such as existing structures, ancient trees, cultural relics and historic sites, etc., most of these structures can not be relocated and demolished, so the protection of the existing important structures in the excavation process of the foundation pit, and the strict control of its deformation are the major difficulties in the tunnel design process.

Scholars at home and abroad have carried out a lot of research on the excavation of foundation pits and the direction of adjacent structures. For example, Ding Huaxing et al. [1] used the ADINA finite element program and on-site monitoring to conduct a comprehensive analysis of the new subway station passing under the existing subway station, and analyzed the structure and operation safety of the existing subway station. Huang Wenbin et al. [2] used elastic theory calculation, three-dimensional numerical simulation method and automatic monitoring method to analyze the deformation of foundation pit support structure and subway elevated line. Peng Zhijia et al. [3] used PLAXIS 3D to study the three-dimensional numerical simulation of the support stress characteristics of deep foundation pits under unbalanced loads. Rui Yongqin et al. [4] studied the influence of the construction of subway station foundation pit group on the stability of the adjacent bridge high-speed railway foundation. Xu Guoyuan et al. [5] deduced the calculation formula of the additional stress at the tunnel due to the unloading action of foundation pit excavation based on the Mindin classical solution. Wang Hao et al. [6] introduced the design and selection of support for the super-large deep foundation pit adjacent to the subway under complex environment and weathered rock conditions, and discussed the rationality and scientificity of the support design through the analysis of foundation pit monitoring and field effect. Yang Gongbiao [7] took shallow buried tunnels in cavity-bearing strata as the research object, and comprehensively used model tests, theoretical analysis and numerical simulation to study the mechanical interaction mechanism between stratum cavities and shallow buried tunnels, as well as the deformation law and failure characteristics caused by strata. Dai Bingqiang et al. [8] analyzed the deformation of the expanded loess foundation pit and the response characteristics of the adjacent structures in the loess deep foundation pit project, which had been interrupted for several years.

At present, experts at home and abroad mostly study the impact on adjacent tunnels in the process of foundation pit excavation, but do not elaborate the problem from the perspective of soil-junction mechanism, and do not put forward relevant suggestions for the protection of important structures. Based on this, this paper first identifies and evaluates the risk sources according to the risk classification criteria, and then performs three-dimensional numerical calculation and simulation of the foundation pit-subway viaduct to determine the impact of the foundation pit construction process on the adjacent subway viaduct, and then proposes corresponding protection measures for the subway viaduct, which also provides a basis for the classification standard of risk level.

2. Project Overview

Chinese Wuxi-Taicang Expressway (Wuxi to Suzhou section), the route starts from Wuxi North Hub, passes through the control corridor of Wuxi Huishan Planning Area, to Bashi and Xibei Town, along the north of Wuxi Xishan'an Town, crosses the Wangyu River at the junction of Wuxi and Suzhou, and crosses the Wangyu River along the Nanhu Dang side to Xinzhuang Planning Area, the route passes through the gap in the planning area, and ends at the west of Xiangcheng Industrial Zone connecting to the Northwest Ring Expressway of Suzhou, with a total length of 49.77km. The Huishan New Town Tunnel Project is laid from west to east, basically along the existing Jinhui Road. The starting point of the tunnel is from the east side of Wuyun Road, and it crosses Huiyuan Road, Huishan Avenue, Metro Line 1 (Yanqiao Station ~ Xibei Canal Elevated Section), Baiqugang River Road, and Xicheng Expressway and exits the ground. The horizontal and longitudinal view of the Huishan New Town Tunnel is shown in Figure 1. The Huishan Xincheng Tunnel adopts the two-way six-lane expressway standard with a design speed of 100km/h, the boundary of the construction tunnel is shown in Figure 2, and the contour diagram in the standard section is shown in Figure 3.

Figure 1: Horizontal and vertical view of Huishan New City Tunnel

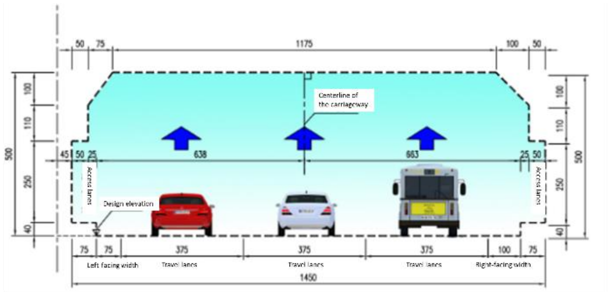

Figure 2: Schematic diagram of the building boundary of a two-way six-lane tunnel

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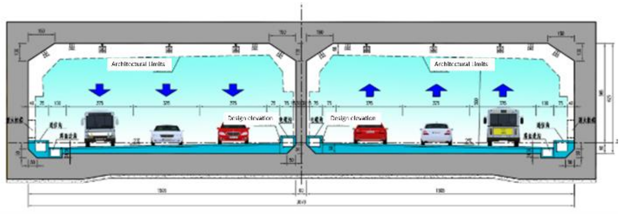

Figure 3: Architectural boundary and inner contour plan of the buried section of the tunnel (standard section)

The proposed Wuxi-Taicang Expressway Huishan New Town Tunnel passes under the viaduct of Wuxi Metro Line 1 (Yanqiao Station ~ Xibei Canal Station), the excavation depth of the foundation pit is about 10.5m, and the closest distance between the foundation pit and the viaduct pile foundation is about 8.7m. The subway viaduct at the proposed tunnel is shown in Figure 4.

Figure 4: Metro viaduct at the proposed tunnel

3. Risk assessment

3.1. Determination of risk levels and acceptance criteria for different levels

The tunnel foundation pit is adjacent to the subway viaduct, and the excavation of the foundation pit may have an adverse impact on the viaduct pile, so the viaduct is one of the important risk sources in the process of foundation pit excavation, and the corresponding risk assessment needs to be carried out. To conduct qualitative analysis of engineering risks, it is necessary to classify the identified risks, and the results of risk classification can provide a basis for the formulation of risk control countermeasures.

Risk assessment is basically divided into two categories, namely the assessment of the probability of risk occurrence and the assessment of the loss caused by the occurrence of risk. The risk occurrence probability levels are divided into 1, 2, 3, 4, and 5, and the criteria for judging each level are shown in Table 1. The risk loss level is divided into 1, 2, 3, 4 and 5 levels, which should be determined according to factors such as the level of casualties, the level of economic loss, and the level of environmental impact. If multiple losses occur at the same time, the risk level is determined based on the principle of high one, and the criteria for judging the risk loss obtained according to each factor are shown in Table 2.

Table 1: Standards for judging the probability of risk occurrence

grade	Quantitative judging criteria	Median	Qualitative judgment criteria
one	$P<0.0003$	0.0001	It's almost impossible to happen
two	$0.0003\leq P<0.003$	0.001	Rarely
three	$0.003\leq P<0.03$	0.01	Happens by chance
four	$0.03\leq P<0.3$	0.1	It can happen
five	$P\geq 0.3$	1	Occurs frequently

Note 1: P is the probability value, when P is difficult to obtain, it can be replaced by the frequency of occurrence in the current year.

2: Quantitative judgment criteria are preferentially used for risk occurrence probability levels, and qualitative judgment criteria can be used when quantitatively cannot be quantified.

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Table 2: Judgment Standard of Risk Loss Level

grade	Casualties / people	Economic loss/million dollars	The number of people who need to be relocated urgently/resettled	Consequences
one	1 Seriously injured	<5	<50	Negligible
two	1 Minor injuries, 1 < serious injuries≤ 10	5~10	50~100	To consider
three	1 Deaths, 1 < minor injuries≤ 10	10~50	100~500	severe
four	1< ≤ 10 deaths and 10 minor >injuries	50~100	500~1000	Very serious
five	deaths >10	>100	>1000	Catastrophic

According to the risk occurrence probability level and the risk loss level, the risk assessment matrix can be obtained, which is shown in Table 3.

Table 3: Risk assessment matrix

The probability of the risk occurring	Risk of Loss				
	one	two	three	four	five
one	I	I	II	II	III
two	I	II	II	III	III
three	II	II	III	III	IV
four	II	III	III	IV	IV
five	III	III	IV	IV	IV

Note: Refer to the International Tunnelling Association"Guidelines for Tunnelling Risk Management".

According to the above table, the risk level of tunnel engineering design is divided into level I (low risk), level II (medium risk), level III (high risk), and level IV (very high risk), and the risk acceptance criteria are shown in Table 4 below.

Table 4: Risk acceptance criteria

Risk level	request
I	The level of risk is acceptable, the current response is effective, and no additional technical, managerial precautions are required
II	The risk level is conditionally acceptable, and further preventive measures are necessary to improve safety
III	The level of risk is conditionally acceptable, countermeasures to mitigate the risk must be implemented, and contingency plans need to be prepared
IV	The level of risk is unacceptable, and effective countermeasures must be taken to reduce the risk level to level III and below, and if the cost of countermeasures exceeds the capacity of the project legal person (owner), the plan is changed or the project implementation is abandoned

3.2. The results of the risk level assessment of the subway viaduct section under the tunnel

According to the above risk level determination criteria, the risk of Huishan New Town Tunnel of Xitai Expressway was comprehensively analyzed, and the risk of foundation pit excavation stage in the early stage of the tunnel was mainly caused by the following two aspects, namely: foundation pit engineering and bridge engineering.

The risks existing in the construction process of the open-cut tunnel are analyzed, and the results of the analysis are as follows. The assessment risk table is shown in Table 5.

1) Risk analysis of foundation pit engineering:

The excavation depth of the foundation pit is about 10.5m, the depth of the foundation pit is large, and the safety level of the foundation pit is level 1, which requires greater lateral displacement of the supporting structure and soil settlement around the foundation pit. Lateral displacement standard: 21mm, vertical settlement displacement standard: 10.5mm.

2) Risk analysis of bridge engineering:

The excavation depth of the foundation pit is about 10.5m, the foundation pit is adjacent to the pile foundation of the subway viaduct, and the minimum distance between the subway viaduct and the foundation pit project is 8.7m, which is less than 1 times the depth of the foundation pit, and there is a risk of excessive deformation and damage to the adjacent viaduct due to the excavation of the foundation pit.

Table 5: Assessment of the risks during the excavation of the foundation pit

Sources of risk	Risk Events	Occurrence probability scale	Risk loss level	Initial risk level
Foundation pit engineering	The deformation of the foundation pit enclosure structure is large	three	three	III
Bridge engineering	The viaduct is damaged by large deformation	two	three	III

3.3. Risk analysis and control

For the potential risks in the project, corresponding control measures should be proposed according to the risk assessment results to reduce the probability of risk occurrence and the losses caused. Feasible and effective control measures are proposed for the risks existing in the construction stage of foundation pit excavation of viaduct small clearance tunnels, as follows:

1) construction plan measures: the foundation pit enclosure structure adopts Φ1000@1200 bored piles for enclosure, the foundation pit is provided with three supports, the first support is 800×800 reinforced concrete support, the transverse spacing is 6.0m, the second and third roads are supported by steel, Φ609 steel pipe support, t = 16, transverse spacing is 3m, the lateral displacement of the foundation pit can be better controlled, and the pile foundation foundation of the viaduct is built adjacent to the foundation pit. The foundation pit near the pile foundation of the adjacent viaduct adopts the waterproof curtain of Φ800 high-pressure jet grouting pile, the soil in the passive zone is reinforced by high-pressure jet grouting pile, and the sleeve valve pipe grouting is used to reinforce within 5m around the viaduct cap. Foundation pit support plan and cross-sectional view are shown in Figure 5, Figure 6 respectively.

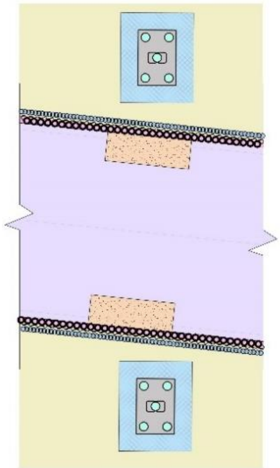

Figure 5: Foundation pit support plan

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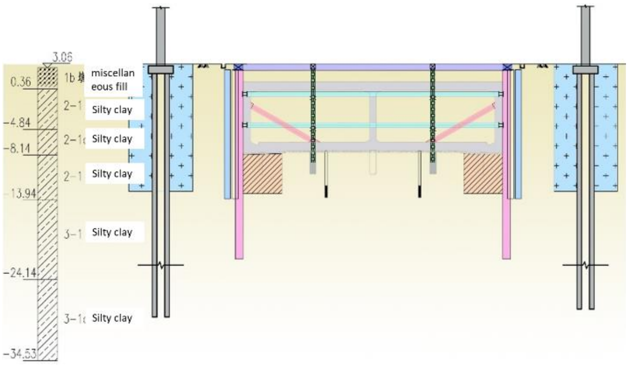

Figure 6: Cross section of foundation pit support

2) theoretical analysis measures: according to the construction plan measures, establish a three-dimensional finite element numerical model, analyze the foundation pit construction stage, to determine the feasibility of the existing foundation pit construction plan, provide a scientific basis for the formulation of the plan.

4. Numerical computational analysis

4.1. Finite element model establishment

According to the geographical location of the foundation pit and the engineering geology, the three-dimensional model was established by Midas GTS NX to simulate the excavation construction process of the foundation pit.

The overall model is 110m× 70m×100m, the bridge pile foundation length is 66m, the cushion cap is 2.5m high, and the pier is 14m high; in the foundation pit support design, the first row of supports are concrete supports (0.8m×0.8m), the second and third rows of supports are steel supports (ø609,16), the diameter of the bored piles is 1.0m, and the pile length is 22m.

In the model, the soil and piers are established by solid elements, the bridge piles and supports are simulated by beam elements, and the enclosure structure is simulated by plate elements, with a total of 88,976 elements. The edge of the model adopts a fixed boundary to constrain the three-way displacement of each node at the edge. Because the calculation range of the base around the model is large enough, the boundary effect can be basically eliminated. The specific model is shown in Figure 7(a)(b) below.

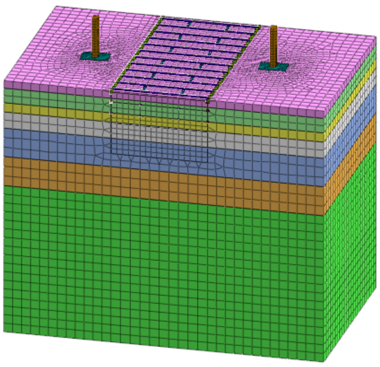

Figure 7(a): Overall finite element model of bridge pile-foundation pit

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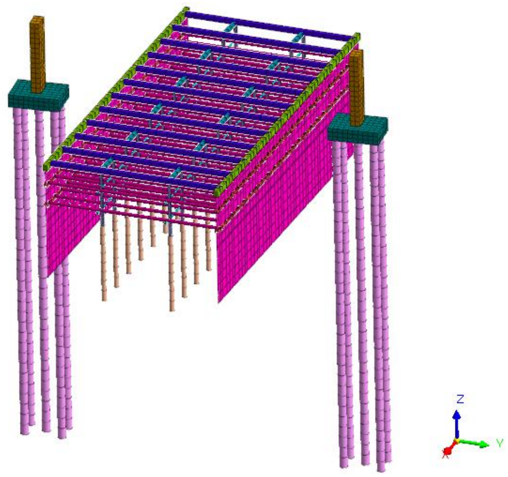

Figure 7(b): Pile foundation and enclosure structure model

4.2. Material constitutive models and calculated parameters

4.2.1. Constitutive relations and parameters of soil layers

The Moore-Coulomb criterion in the elastoplastic model is used for each soil layer of the foundation, which is the constitutive relationship of elasticity-complete plasticity, and its typical stress-strain curve is shown in Fig. 8.

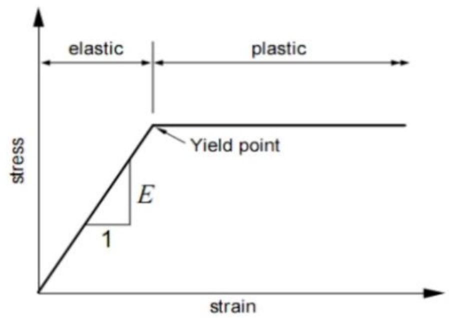

Figure 8: Elastic-fully plastic constitutive model

The mol-Coulomb is expressed as principal stress

$$\sigma_1 \frac{1-\sin\varphi}{2c\cos\varphi} + \sigma_3 \frac{1+\sin\varphi}{2c\cos\varphi} = 1$$

It can also be expressed as:

$$f(J_1, J_2, \theta) = -\frac{1}{3} I_1 \sin\varphi + \sqrt{J_2}(\cos\theta + \frac{1}{\sqrt{3}}\sin\theta\sin\varphi) - c\cos\varphi = 0$$

As shown in Figure 9, the Moore-Coulomb criterion is an irregular hexagonal pyramid in the principal stress space, with a straight meridian and an irregular hexagonal curve in the π plane. Because of its high accuracy in the practical confinement pressure range and its simplicity of use, it is widely used in geotechnical analysis.

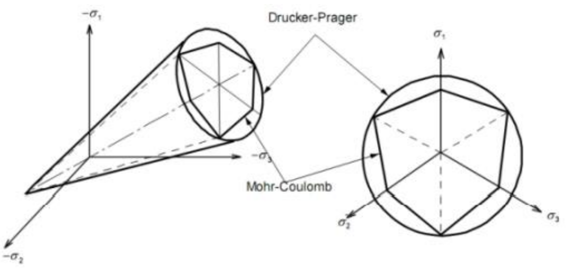

Figure 9: Moore-Coulomb constitutive model

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According to the geological survey report of this project, the first layer of soil in the stratum where the foundation pit at the subway viaduct is located is miscellaneous fill soil, and the rest of the soil layers are silty clay, and the bottom of the foundation pit is located in silty clay. The physical and mechanical parameters of the soil are shown in Table 6.

Table 6: Design parameters of foundation pit support

The name of the soil layer	Severe /(kN/m3)	Cohesion /kPa	Internal friction angle /(°)	Compressive modulus /MPa
miscellaneous fill	15	0	10	3.46
Silty clay	19.9	37.9	14.5	6.48
Silty clay	19.3	18.3	11.4	5.44
Silty clay	19.9	37.9	14.5	6.48
Silty clay	19.9	42.0	15.0	7.91
Silty clay	18.9	19.5	11.3	4.75

4.2.2. Constitutive relations and parameters of steel and concrete

The constitutive relationship between steel and concrete is expressed using an ideal elastic model: $\sigma = E\varepsilon$.

The physical parameters of steel and concrete are taken according to the specification, as shown in Table 7 below:

Table 7: Steel and concrete physical parameters

material	density /(kg/m3)	Elastic modulusE/GPa	Poisson's ratio
C30 concrete	2450	30.0	0.169
steel	7830	200	0.3

4.2.3. Calculate the load parameters

In the process of foundation pit excavation and support construction, the system is affected by the gravity field, and the upper load of the bridge pier is considered to be 40kPa.

4.3. Calculation results

4.3.1. Initial in-situ stress analysis before foundation pit excavation

Before the excavation of the foundation pit, the soil and underground structure are in a state of equilibrium as a whole. When the foundation pit is excavated, the excavation face is unloaded, which changes the interface and stress state of the original soil foundation, and the change of this stress state will cause the change of the internal force of the underground structure. Therefore, in order to study the internal force and deformation of the bridge structure during the excavation of the foundation pit, it is necessary to study the change of stress state in the soil first. Before the construction of the enclosure structure, the initial in-situ stress balance is carried out on the bridge structure and the surrounding soil, and the soil stress balance before excavation is shown in Figure 10.

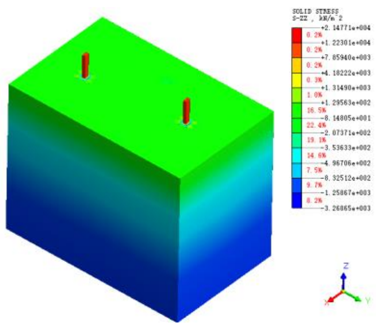

Figure 10: Initial ground stress balance stress cloud diagram

From the initial in-situ stress equilibrium state before foundation pit excavation, it can be seen that the stress concentration occurs at the corner of the pier and the cushion cap, and the initial stress is larger. The stress in the soil layer is in a layered state, which is consistent with the actual formation stress

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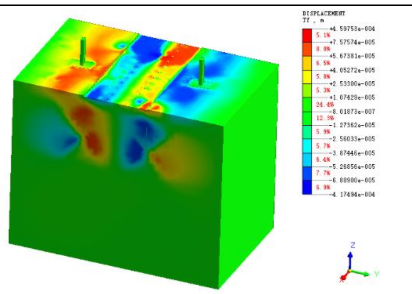
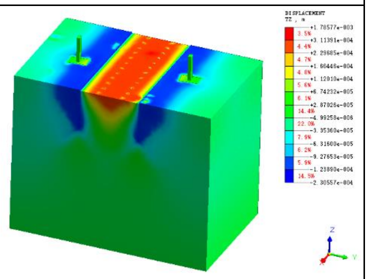
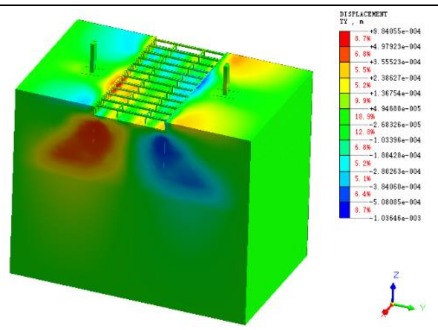
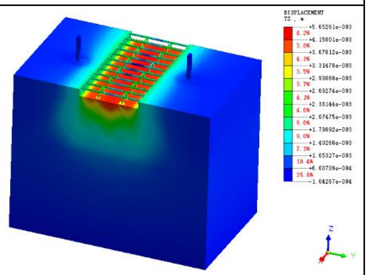
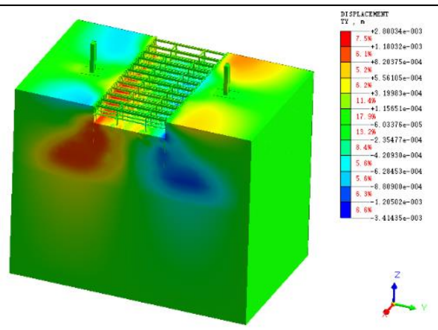
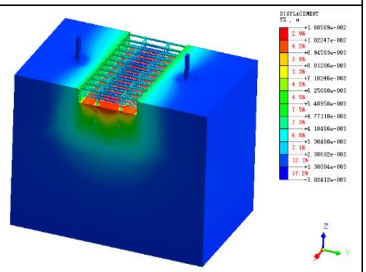
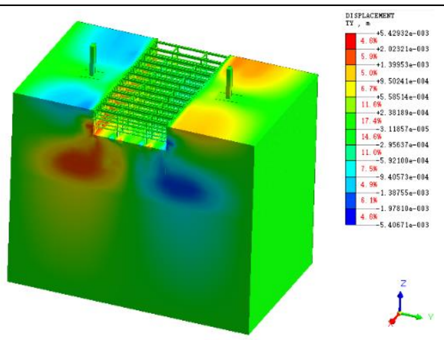
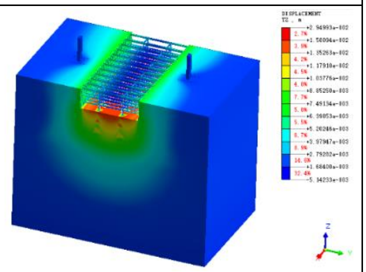
distribution state, which verifies the accuracy of the initial model.

4.3.2. Analysis of the overall displacement of the model during the excavation of the foundation pit

The horizontal and vertical displacement contours of each stage of the model are given in turn according to the excavation order of the foundation pit, as shown in Table 8 below, where the Z direction of the model is the depth direction and the Y direction is the transverse direction of the foundation pit.

Table 8: Model displacement cloud map during foundation pit excavation

Calculation steps	Horizontal displacement contour of the model	Calculation steps	Vertical displacement contour of the model
Stage 1: Excavation of the first layer of soil	 UYmax=0.42mm	Stage 1: Excavation of the first layer of soil	 UZmax=1.79mm
Stage 2: Apply the first support and excavate the second layer of soil	 UYmax=1.04mm	Stage 2: Apply the first support and excavate the second layer of soil	 UZmax=5.65mm
Stage 3: Apply the second support and excavate the third layer of soil	 UYmax=3.42mm	Stage 3: Apply the second support and excavate the third layer of soil	 UZmax=16.86mm
Stage 4: The 3rd support is applied and the 4th layer of soil is excavated	 UYmax=5.43mm	Stage 4: The 3rd support is applied and the 4th layer of soil is excavated	 UZmax=29.50mm

As can be seen from the above table, the horizontal and vertical displacement cloud diagram after foundation pit excavation shows that the horizontal displacement of the soil around the pit will be caused during the excavation of the foundation pit, and the maximum horizontal displacement is about 5.43mm. At the same time, after the excavation of the soil inside the foundation pit, it will cause a small settlement

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on the surface around the foundation pit, and the displacement settlement value is about 7mm. After the excavation of the soil body in the pit, due to the stress release, the bottom soil of the pit has a slight uplift trend, and the bottom of the pit can be considered to be partially reinforced when the foundation pit enclosure scheme is selected.

4.3.3. Analysis of pile deformation and internal force around foundation pit

Due to the action of active earth pressure, the enclosure structure is subjected to the action of active earth pressure, and the lateral displacement occurs in the pit, and the in-situ stress is released and redistributed, causing the bridge structure to move laterally, and the soil around the foundation pit and the bottom of the pit is unloaded due to the excavation of the foundation pit, and the lateral displacement of the foundation pit and the bottom uplift, resulting in the change of the internal force of the bridge pile foundation structure.

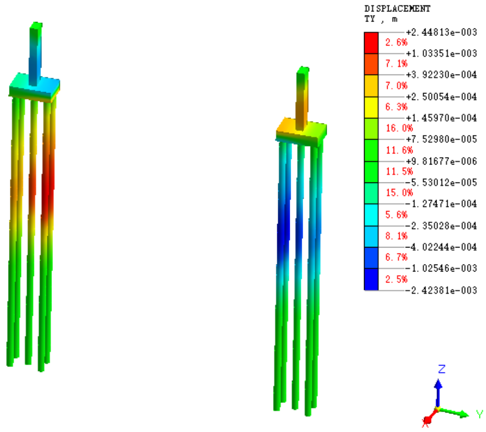

Figure 11(a): Horizontal displacement diagram of bridge piers and bridge piles

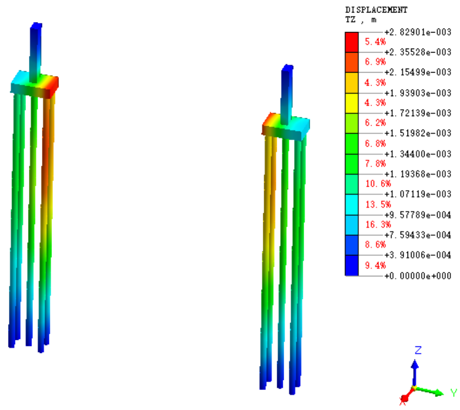

Figure 11(b): Vertical displacement diagram of bridge piers and piles

After the foundation pit is excavated to the bottom of the pit, the horizontal and vertical displacement of the bridge pile is shown in Figure 11 (a) (b), from the figure, the maximum horizontal displacement of the bridge pier and the bridge pile is about 2.45mm, and the maximum vertical displacement of the bridge pier and the bridge pile is about 2.83mm. The displacement of the bridge structure is an index to measure the impact of foundation pit excavation on the existing important structures, and the existing structures should be ensured as far as possible from the influence of foundation pit excavation. The deformation control of the bridge structure is shown in Table 9 below.

Table 9: Bridge structure deformation control table

Direction of the maximum displacement and location		Displacement value(mm)	Control criteria(mm)	Whether it is satisfied
Pier piles	Horizontal displacement	2.45	5	Yes
	Vertical displacement	2.83	5	Yes

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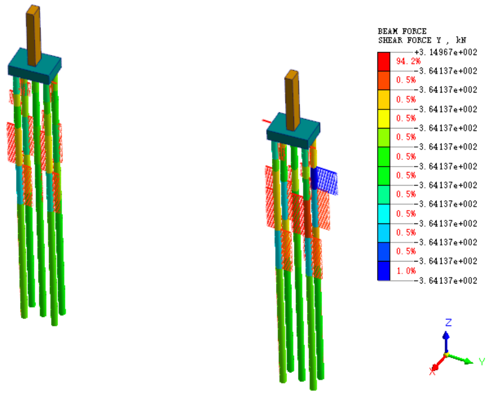

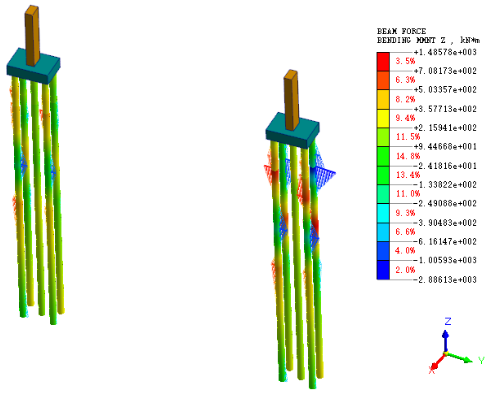

Figure 12(a): Bridge pile shear force diagram

Figure 12(b): Bridge pile bending moment diagram

According to the shear force diagram and bending moment diagram of the metro viaduct pile foundation, *Figure* 12(a)(b), the maximum shear force of the pile foundation is 364.14kN, and the maximum bending moment is 2886.13kN.m, and the internal force of the bridge pile provides a reasonable basis for the formulation of bridge pile protection measures.

4.3.4. Analysis of deformation and internal force of the support system in the foundation pit

After the foundation pit is excavated to the bottom of the pit, the retaining structure will be deformed due to the lateral earth pressure, and the displacement contour diagram of the enclosure structure is shown in Figure 13 below.

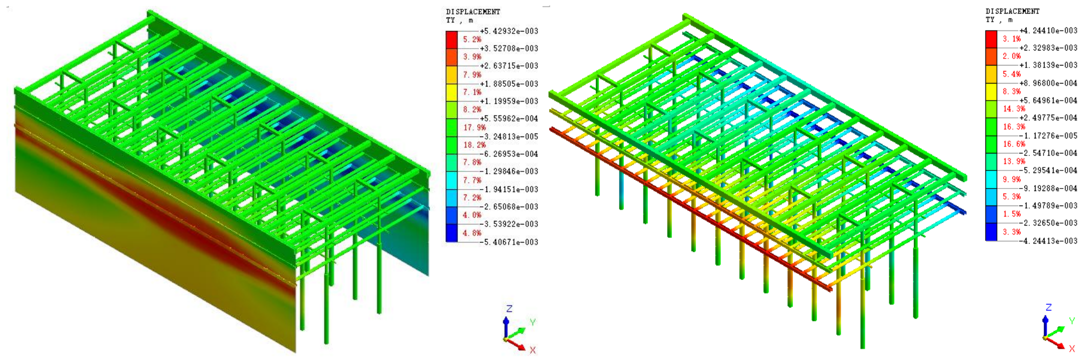

Figure 13: Cloud diagram of horizontal displacement of enclosure structure

It can be seen from the horizontal displacement contour diagram of the enclosure structure that the maximum horizontal displacement of the enclosure structure is 5.43mm<20mm, which meets the horizontal deformation standard of the first-class foundation pit enclosure structure. The control parameters of foundation pit soil and enclosure structure are shown in Table 10 below.

Table 10: Main control parameters of foundation pit displacement

Excavation displacement	displacement(mm)	Control criteria(mm)	Whether it is satisfied
Lateral displacement of the envelope	5.43	20	Yes
Surface subsidence	7	10	Yes

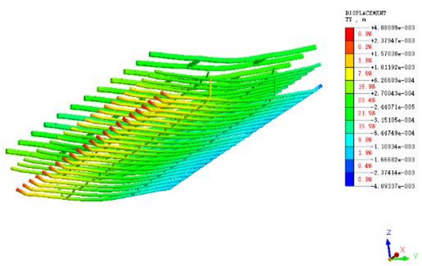

Figure 14(a): Support system deformation state diagram

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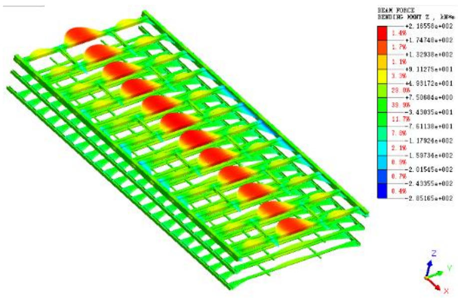


Figure 14(b): Bending moment diagram of support system

From the deformation and bending moment diagram of the support system, Fig. 14(a)(b), it can be seen that Mmax=285kM.m, the internal force at both ends and the middle part of the support is larger, and it can be seen from the deformation diagram that the deformation of the third steel support is larger, so attention should be paid to the selection of the third support structure.

5. Comparative analysis of the displacement of retaining piles

The deformation of the enclosure pile is related to the overall safety of the foundation pit, and has an important impact on the safety of the subway bridge pile near the foundation pit. Therefore, it is necessary to study the deformation of enclosure piles. Fig. 15 shows the deformation state of the pile in the numerical simulation under different excavation conditions. The numerical simulation results under different excavation conditions, the traditional elastic theory calculation results, and the monitoring data during the construction process of a similar actual project are compared and analyzed for the displacement of the retaining pile, and the comparative analysis curve is shown in Figure 16.

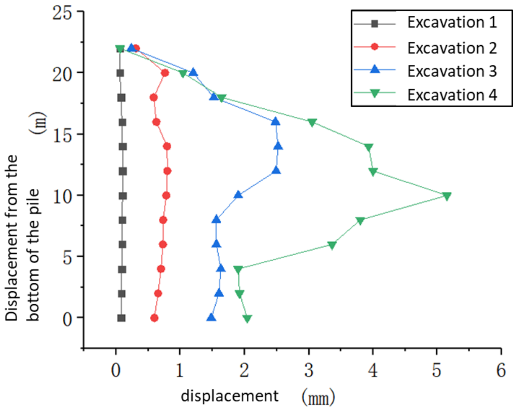
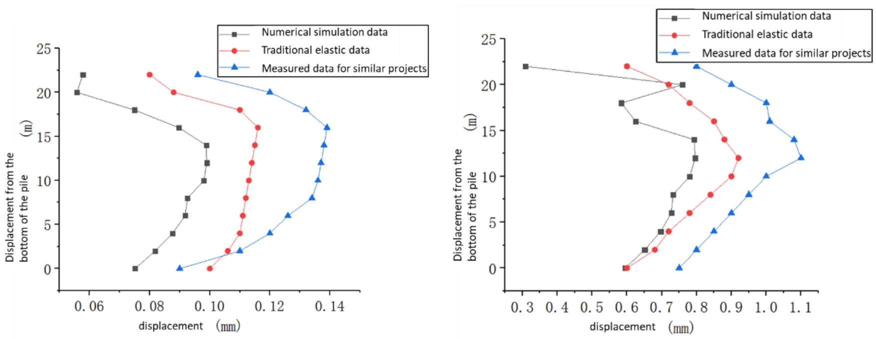


Figure 15: Deformation state of pile body in numerical simulation under different excavation conditions

As can be seen from Fig. 15, the deformation law of the pile in the numerical simulation under different excavation conditions is basically the same, but there is a clear difference in the numerical value, and the larger the excavation depth, the greater the pile deformation. And the maximum deformation of the pile is near the bottom of the foundation pit.



(a)Excavation 1 case *(b)Excavation 2 working conditions*

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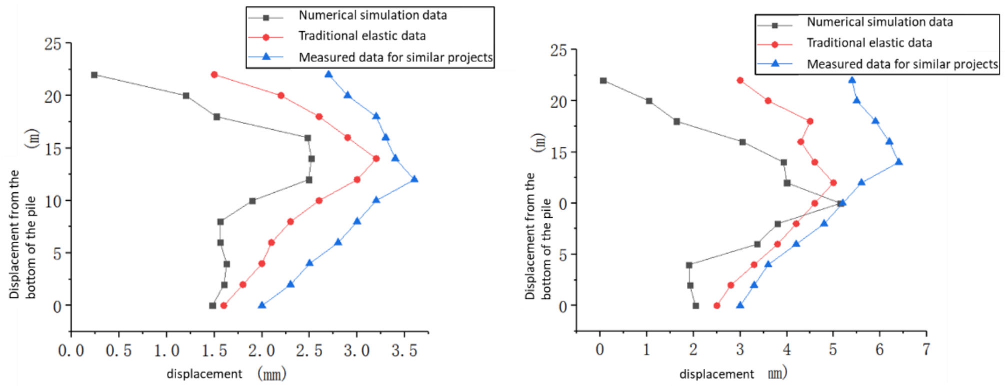

(c)Excavation 3 working conditions *(d)Excavation 4 working conditions*

Figure 16: Deformation comparison curves of retaining piles under different excavation conditions

It can be seen from Fig. 16 that the numerical simulation data, the traditional elasticity method data and the measured data of similar projects under different excavation conditions are basically the same, the maximum displacement of the pile body at the bottom of the pit, and the displacement of the pile top and the bottom of the pile is smaller, mainly because the pile top is supported by concrete, the supporting stiffness is larger, and the active earth pressure of the soil layer is smaller. Due to the large passive earth pressure at the bottom of the pile, the reaction force against deformation is larger, so the displacement of the pile bottom is small. It can also be seen from the figure that the numerical simulation data is significantly smaller than the traditional elasticity method and the measured data, and the data value obtained by the measured project is the largest, so when using numerical simulation to evaluate and calculate the safety of the foundation pit, the simulation results can be considered to be appropriately amplified, and the amplified results will be closer to the real deformation value of the retaining pile.

6. Conclusion

In this paper, the key nodes of the tunnel under the subway viaduct in the Huishan New Town section of the Xitai Expressway are studied, and the risk source identification, risk level classification and risk control measures are formulated. Using three-dimensional numerical simulation, the influence of the excavation of the adjacent viaduct with small clearance foundation pit on the viaduct pile foundation was studied, and combined with the elastic method calculation and the measured data, the following conclusions were drawn:

1) The excavation of the foundation pit will have an impact on the adjacent viaduct piles, and through the identification of risk sources, the foundation pit engineering and bridge engineering are the main risk sources of the project, and the initial risk level of the two is level III.

2) By establishing the finite element three-dimensional model of foundation pit and viaduct, the maximum horizontal displacement of the viaduct is 2.45mm, the maximum vertical displacement is 2.83mm, the maximum horizontal displacement of the foundation pit retaining pile is 5.43mm, and the maximum vertical displacement is 7.00mm, which meets the requirements of the specification through the calculation.

3) The displacement data of the enclosure pile obtained by numerical simulation are compared with the calculation data of the traditional elastic method and the actual monitoring data of a project, and the displacement law reflected in the three is consistent, the displacement of the pile in the pile, that is, the position of the bottom of the foundation pit, is the largest, and the displacement value of the pile top and the pile bottom is relatively small.

4) When the distance between the viaduct pile foundation and the foundation pit is close, the support form of row pile + inner support is used to cooperate with the local soil reinforcement, which has a large foundation pit support stiffness, and has a good effect on the protection of important structures.

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