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Numerical analysis and optimization of the subway station deep foundation pit support

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ABSTRACT

With the continuous progress of the national construction,all kinds of deep foundation pit emerge in endlessly,in order to study the selection and optimization of the steel brace of retaining structure,in order to Shenyang metro line 9 and line 10 interchange station deep foundation pit engineering as an example.By using numerical simulation method,analyses the support installation position and horizontal distance two data changes on the influence of the excavation process of retaining structures.Through to optimization design and research the foundation pit engineering steel brace system of Shenyang subway interchange station,we get the following conclusion:

(1) The lower the first brace position is,the greater the horizontal displacement of pile top is,the higher the last brace is,the smaller the maximum horizontal displacement of the pile is,but the pit displacement will increase.

(2) Reducing the steel brace horizontal spacing can improve the overall stability of deep foundation pit,it also can significantly reduce the pile position displacement and pile internal force,but the spacing is too small are not conducive to the construction,and increase the project cost.

(3) Compared with the original scheme in the end,it can be found that the optimized the scheme not only can control the deformation within the scope of the allowed,but save the steel, reduce the cost and construction period.

Key words: metro; deep foundation pit; inner support; optimization

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1 Introduction

The construction of deep foundation pit is quite challenging, when happened the problems,it will cause incalculable disaster for the surrounding environment. Combining with Shenyang metro line 9 and 10 line interchange station deep foundation pit engineering in this paper,it optimizes the support system systematically,the optimized scheme on the premise of ensuring project safety enough to save cost,and reduce the engineering cost.

2 Numerical simulation of the foundation pit excavation

The scope of the selection of calculation model is 40.6 m x 27.6mx27.6m (length x width x deep) by Li Zheng deep foundation pit structure design software.The excavation and supporting of foundation pit is divided into four stages,the soil is excavated respectively to-2.4m,-8.4m,-14.2m,-19.7m.The support position is respectively -1.9 m,-7.9m,-13.7m and -19.2m.

3 Support parameters and impact analysis

3.1 The influence of support distribution for retaining structure

The first and the fourth support's location have been adjusted in the numerical simulation,and it comparison analysis.The location of the first support was selected to -1.9m,-3m,the location of the fourth support is chosen at 19.2m and 20.2m respectively.The pile displacement and bending moment are shown in table 1. From the variation of displacement and bending moment can be seen that,the lower the location of the first support,the greater the displacement of pile top,Pile and pile bottom displacement basic no change basically,pile bending moment basically remain unchanged.As can be seen from the data in the table,the first line of support position down will make a displacement increase on the top of the retaining pile,but the effect of the displacement of central and bottom pile is very small.

Table 1 The maximum deformation of pile body of different first brace position

first brace position(m)	displacement of pile top(mm)	displacement of pile(mm)	pile bending moment(KN▪m)
-1.9	2.24	8.12	-691.63～777.35
-3.0	3.06	8.12	-690.01～777.76

Table 2 The maximum pile displacement in different last brace position

the last brace position(m)	displacement of pile (mm)	displacement of pile bottom (mm)	Pile bending moment(KN▪m)
-19.2	8.12	0.33	-691.64～777.35
-20.2	9.62	0.37	-773.53～838.12

The data listed in table 2 is the deformation maximum value for the fourth support of retaining structure in different locations.As can be seen from the data in the table,the fourth support position down will make the displacement and bending of retaining pile increase.

3.2 The influence of support for retaining structure horizontal spacing

we select 1.5 m,2.5 m,3.25 m,4 m,5 m steel brace horizontal distance for

numerical simulation and analysis.The maximum pile deformation and bending moment of different steel brace spacing are listed in table 3.It can be easily seen from the table,changing the steel brace horizontal spacing has bigger influence on the pile deformation.But too much to reduce steel brace horizontal distance will increase the amount of using steel brace,at the same time it makes the inside of the foundation pit construction space smaller,it is bad for foundation pit construction, it can also increase the project cost. So we must grasp the steel brace horizontal distance well.

Table 3 The maximum pile deformation in different support horizontal spacing

spacing (m)	displacement of pile top (mm)	displacement of pile bottom (mm)	Pile bending moment (KN▪m)
1.5	6.78	0.36	-863.48～762.77
2.5	7.43	0.34	-769.74～773.80
3.25	8.12	0.33	-691.64～777.35
4	8.51	0.32	-647.08～779.28
5	9.45	0.31	-645.71～794.80

4 Optimization and analysis of steel support scheme

In order to reduce the project cost as the objective, we optimize the steel brace of the interchange station deep foundation pit engineering in this article.

Table 4 The list of steel support parameter optimization

optimization project	original scheme	optimization scheme
steel brace position（m）	-1.9、-7.9、-13.7、-19.2	-1.9、-7.9、-13.7、-18.2
steel brace horizontal spacing（m）	3.25	4
prestressing ratio	50%	60%

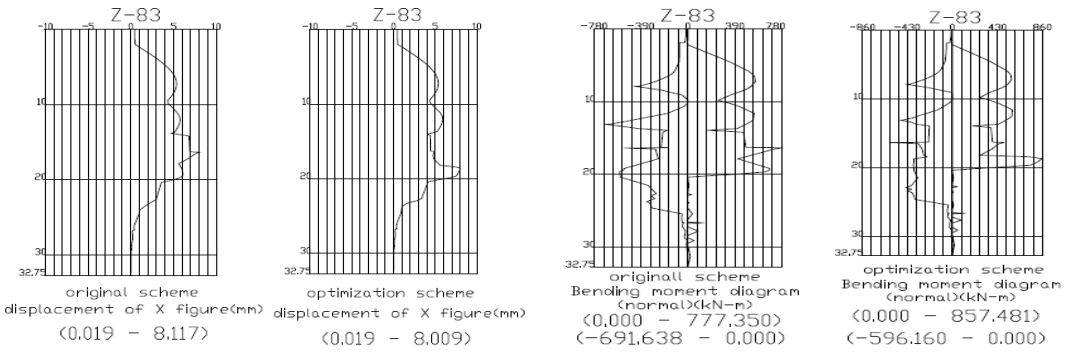

Fig.1 The pile displacement and pile bending moment of the original and optimized scheme

Table 5 The maximum deformation and internal force of retaining structure of the original and optimized scheme

scheme	displacement of pile top (mm)	pile displacement (mm)	Displacement of pile bottom (mm)	pile bending moment (KN▪m)
original	2.24	8.12	0.33	-691.64～777.35
optimization	2.33	8.01	0.29	-596.16～857.48

The optimized scheme date is obtained by numerical simulation, compared with

the original scheme, the results are as follows. It's easy to see, after we optimize the construction scheme,the pile top displacement increased from 2.24 mm to 2.33 mm. Due to the increase of steel brace horizontal spacing,it makes the whole deep foundation pit stiffness decrease, it also makes the pile top displacement and internal force increase. But the retaining pile displacement reduced, the maximal displacement reduces from 8.12mm to 8.01mm.

From the above, optimization scheme on the premise of meet the deep foundation pit construction safety, it improves the retaining pile deformation, at the same time it reduces the engineering cost, convenient for construction, improves The various aspects of economic benefit.

5 Conclusion

Through to optimization design and research the foundation pit engineering steel brace system of Shenyang subway interchange station, we get the following conclusion:

(1) The lower the first brace position is, the greater the horizontal displacement of pile top is, the higher the last brace is, the smaller the maximum horizontal displacement of the pile is, but the pit displacement will increase. So we should raise the first and last brace height in the permitted range as far as possible when we design.

(2) Reducing the steel brace horizontal spacing can improve the overall stability of deep foundation pit, it also can significantly reduce the pile position displacement and pile internal force, but the spacing is too small are not conducive to the construction, and increase the project cost.

(3) The optimized construction scheme improves the stability of the retaining structure, reduces the cost of the project, and makes the construction more simple.The optimized scheme not only achieves the desired purpose, but also highlights the importance of information in engineering.

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