Performance Optimization of Deep Excavation Projects under Complex Geological Conditions in Wuhan

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ABSTRACT

Deep foundation pit construction project is one of hot and difficult problems in rock soil engineering. How to control the deformation of the pits effectively and economically is what we all want. Retaining structure deformation of foundation pit is an important factor on the deformation of foundation pit. Reference of domestic and foreign research and the experience of similar projects, combined with the characteristics of Wuhan project, calculation, analyses and compared two design options and there were some meaningful conclusions.

INTRODUCTION

This project has 9 floors, including 2 basements (some palaces are 3 basements). The basement floor -17.20 meters depth. At the second basement, maximum load of column is 15.000 kN. At the third basement, maximum load of column is 16.500 kN. Above structure of the building total load is 786.000 kN, and underground structure is 451,000 kN. Above structure of the building area is 22.512m2, and underground structure is 43.652 m2, as shown in figure 1.

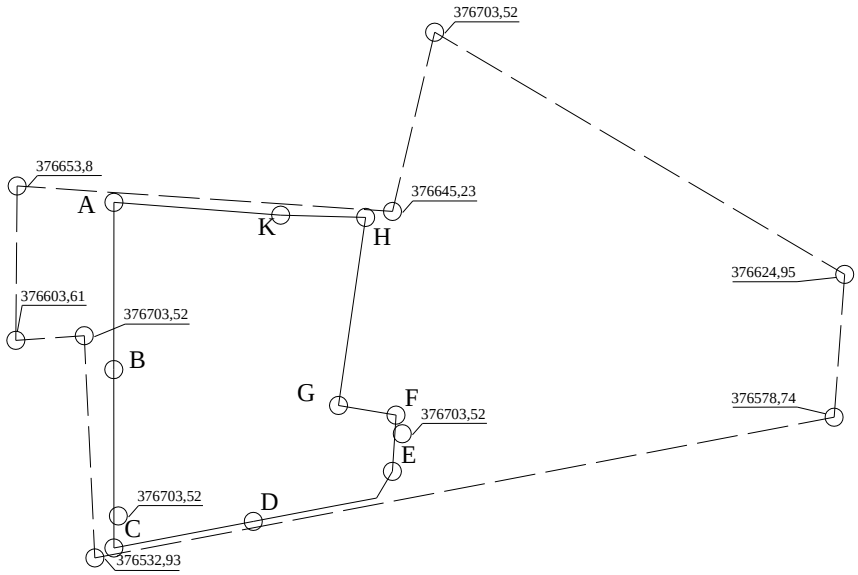

Figure 1. Project site layout

According AB section detail, project geological, hydrological conditions and the surrounding environment conditions, put forward multiple supporting structure design options: Option 1 is pile-anchor support [1-2]; option 2 is double-row piles [3-4]. This paper using Lizheng software [5-6] for the calculation of AB section construction process. Compare the results of two options, then chosed the best of option.

OPTION 1: PILE-ANCHOR SUPPORT DESIGN AND CALCULATION

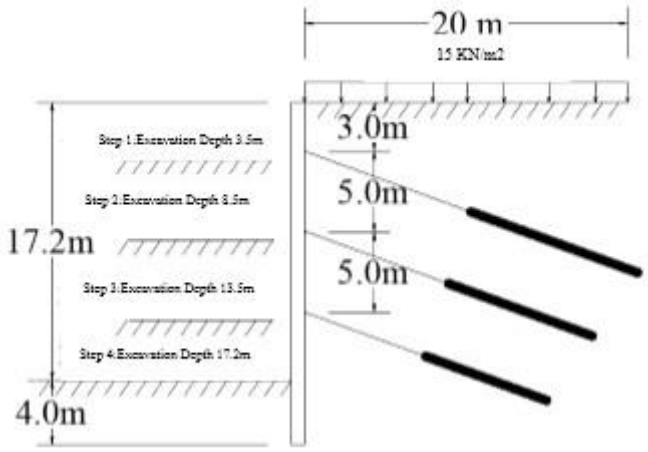

Figure 2. pile-anchor support calculation diagram

Main characteristic of pile-anchor support system is use anchor support instead of the foundation pit horizontal struts, and provide supporting pile tension, reduce the displacement and internal force of supporting pile, and extent permitted to control the deformation of foundation pit. The scheme of calculation diagram as shown in figure 2.

According to geology report, drilling holes and combined with the relevant specifications, documents, determine the foundation rock and soil layer design parameters are shown in table 1. Calculated parameters input and output results by Lizheng software are shown in table 2 ~ 5 and figure 3.

Table 1. Soil physics and mechanics calculation parameter

Layer	Soil	Layer Thickness (m)	γ (kN/m^3)	Cohesive force (kPa)	Angle of internal friction (^{0})
1	Back fill	1.8	19.5	8.0	12.0
2	Clay	5.0	19.7	40.2	16.2
3	Clay, gravel	2.5	18.5	27.9	11.4
4	Red clay	10.7	17.8	38.7	15.7
5	Siliceous rocks and quartz sandstone fracture zone	20.0	22	3000.0	36.0

Table 2. Basic data for calculating foundation pit

Internal force calculation method	The incremental method	The pile spacing (m)	1.2
Specification	Deep foundation pit engineering in Wuhan guide series	The concrete strength grade	C30
Foundation pit level	Level 1	Presence of crown beam	Yes
Pile top leve (m)	0	Crown beam width (m)	1
Depth of foundation pit H(m)	17.2	Crown beam height (m)	0.6
The depth of the fixing (m)	4	The level of the lateral stiffness (MN/m)	7.467
Importance coefficient of foundation pit side wall □□	1.1	Supporting structure on the level of concentration	0
Pile cross section type	circular	The number of load	1
The pile diameter (m)	0.8	Put the slope series	0

Table 3. Anchor detail

Anchor row number	Anchor type	Horizontal distance (m)	Vertical distance (m)	Angle of incidence (^{0})	Total length (m)	Anchor length (m)
1	anchor	1.2	3	20	22	9
2	anchor	1.2	5	20	19	8
3	anchor	1.2	5	20	16	6

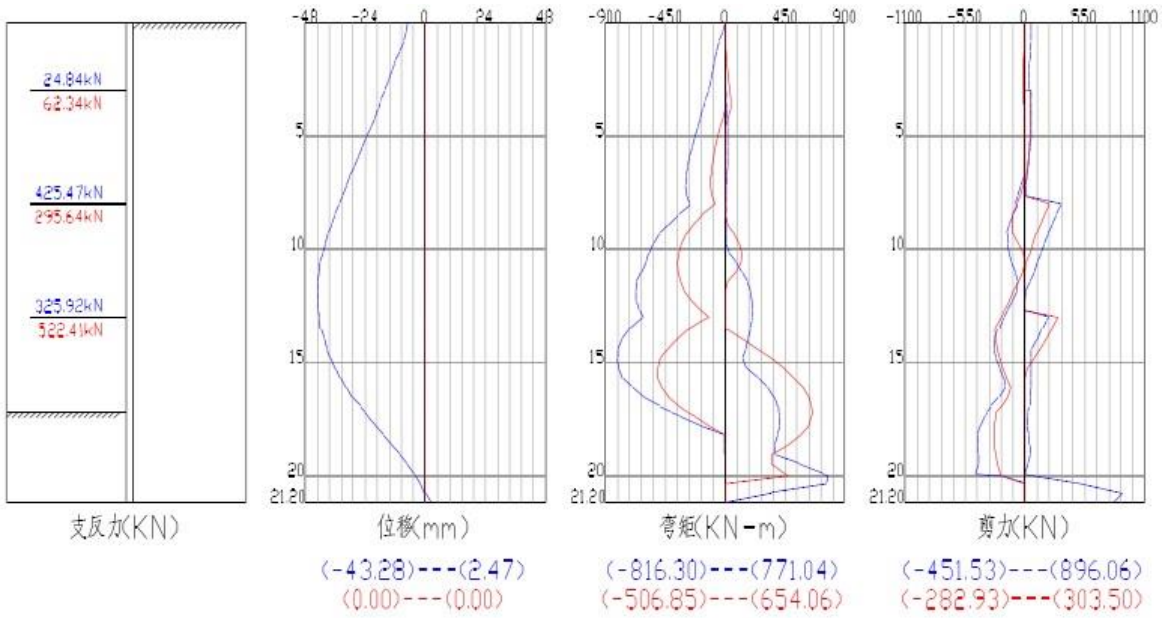

Figure 3. Results after excavation

Results Calculated shown in figure 3, at depth 17.2 m in foundation pit of the maximal displacement of 43.28 mm, maximum bending moment of 896.06kN.m.

Table 4. Reinforcement of pile wall

Reinforcement type	Level	Reinforced detail	Real calculation area (mm^2 or mm^2/m)
longitudinal bar	HRB335	22ϕ25	10799[10416]
stirrup	HRB335	ϕ 20@150	4189[3760]
Strengthen the stirrup	HRB335	ϕ14@2000	154

Table 5 Anchor reinforcement table

Anchor row number	Anchor type	Steel bar and reinforced	The free length (m)	Anchor length (m)	Real calculation area (mm^2)	Anchor stiffness (MN/m)
1	anchor	1ϕ16	13	9	201[107]	2.69
2	anchor	2ϕ36	11	8	2036[1826]	29.37
3	anchor	2ϕ32	10	6	1608[1399]	26.30

DOUBLE ROW PILES DESIGN CALCULATION

Double row piles design calculation diagram as shown in figure 4. Lizheng software calculated parameters input and output results are shown in table 6 ~ 8 and figure 5

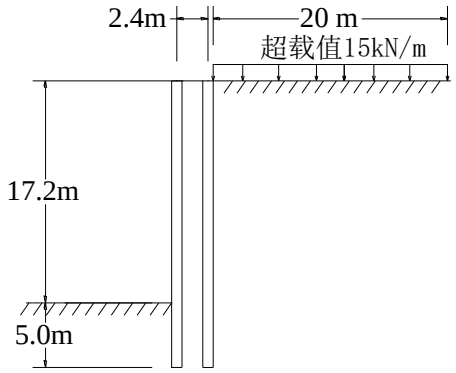

Figure 4 Double row piles and calculating diagram

Table 6 Basic data for calculating foundation pit

Internal force calculation method	The incremental method	Even the beam width (m)	1.2
Specification	Construction of foundation pit supporting technology procedures	Crown beam width (m)	1
Foundation pit level	Level 1	In the front row pile presence of crown beam	Yes
The relative elevation of pile head (m)	0	Crown beam width (m)	1.2
Depth of foundation pit H(m)	17.2	Crown beam height (m)	0.6
The depth of the fixing (m)	5	Horizontal lateral just (MN/m)	7.467
Importance coefficient of foundation pit side wall γ_0	1.1	Back row pile presence of crown beam	Yes
Pile cross section type	Circular	Crown beam width (m)	1.2
Diameter of pile (m)	1.0	Crown beam height (m)	0.6
Pile spacing (m)	1.8	Horizontal lateral just (MN/m)	7.467
Piles row distance (m)	2.4	The number of overload	1
Strength grade of concrete	C30	Put the slope series	0

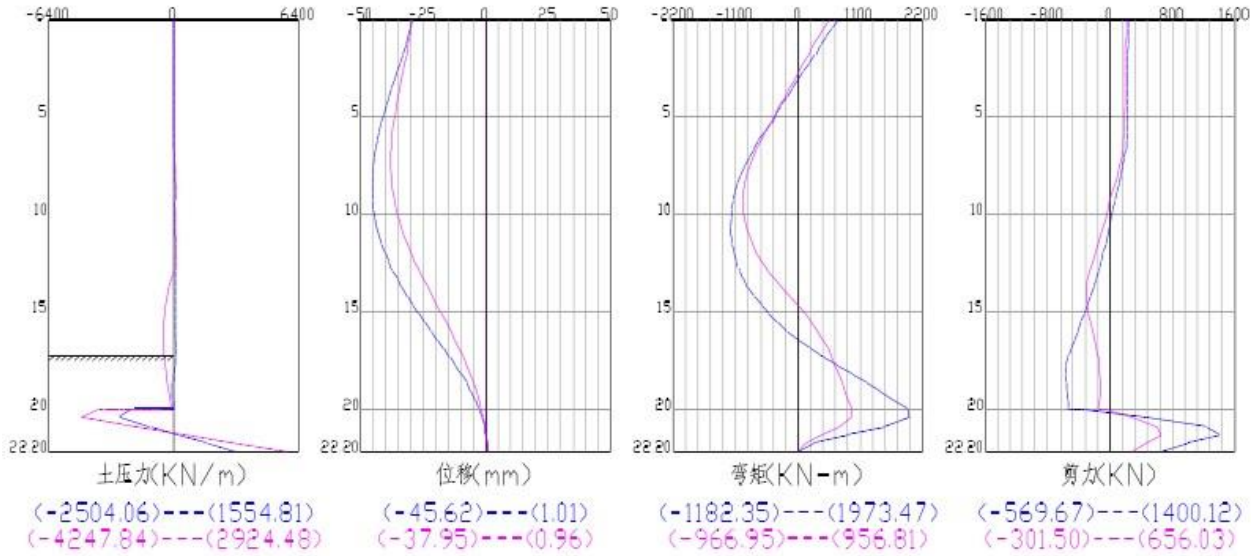

Figure 5 Results after excavation

Results Calculated shown in figure 5, at depth 17.2 m in foundation pit the maximal displacement of 45.62 mm, maximum bending moment of 1973.47 kN. m.

Table 7 Reinforcement of the first row pile

Choose reinforcement type	level	Reinforced detail	Real calculation area (mm^2 or mm^2/m)
longitudinal bar	HRB335	23ϕ36	23411[21500]
stirrup	HRB335	ϕ 25@150	6545[5082]
Strengthen the stirrup	HRB335	ϕ 14@2000	154

Table 8 Reinforcement of the second row pile

Choose reinforcement type	level	Reinforced detail	Real calculation area (mm^2 or mm^2/m)
longitudinal bar	HRB335	26ϕ22	9883[9630]
Stirrup	HRB335	ϕ 12@150	1508[1136]
Strengthen the stirrup	HRB335	ϕ 14@2000	154

CONCLUSIONS

Exampled by Wuhan deep foundation pit supporting project as engineering background, using Lizheng software to calculate the pile-anchor support and double row piles option. Comparative analysis of pile - anchor support option and double row piles support option, both of which can ensure the security and stability of foundation, but the cost of pile-anchor support is far below the double-row piles support, therefore the project selected the pile anchor supporting plan as the actual construction plan.

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