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Research Article

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Deformation monitoring and analysis of deep foundation pit of Xiaoshan rainbow Boulevard

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ABSTRACT

Based on the deep foundation pit engineering of Xiaoshan rainbow road as an example, combining with the monitoring report, gather the data of lateral displacement of foundation pit in the deep soil, settlement and ground settlement enclosure , exploratory excavation in the construction process of deep soil displacement and deformation, and puts forward some advices of improving the deformation of foundation pit.

Key words: Deep foundation pit; Deep soil displacement; Settlement

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INTRODUCTION

Since twenty-first Century, the city building develop toward the direction to air and underground space , deep foundation pit engineering construction projects as a widely used. But in foundation pit construction become the priority among priorities in construction safety ,because ofvarious reason frequent accidents in process . Therefore, the foundation pit monitoring work is indispensable in the construction of deep foundation pit.`

1 ENGINEERING GENERAL SITUATION

This works for the tunnel digging a two-way six lane, buried length is 354m, the main use of single box double cell concrete box structure. Tunnel cross section clearance size width 29.1m height 5.990m, unilateral lane boundaries size width 12.00m and height 5.0m. Design of foundation pit excavation depth of 10.0m ~ 14.20m.

1.1 GEOLOGICAL CONDITIONS

The foundation soil from top to bottom: shallow gray, grayish yellow clayey silt, silty clay silt, sandy silt; middle neritic gray, dark gray silty clay; down gradually over the middle gray, lower the lithology is light gray ,gray ,pale yellow powder sand, gravel, good sorting. The geological conditions are as shown in figure 1.

1.2 HYDROGRAPHIC CONDITIONS

The north of project site built Mong Kok City second phase project, two layer underground, excavation depth of 10.7~12.1m, the retaining structure use of the 1000 diameter bored pile and three shaft stirring pile. The basement structure has been completed.

The south of project is Mong Kok city first phase. Three high-rise residential buildings, pile diameter 600~800 bored pile basement, excavation depth of 6.9m, the retaining structure of the soil use nailing wall, soil nail length 9-15m.

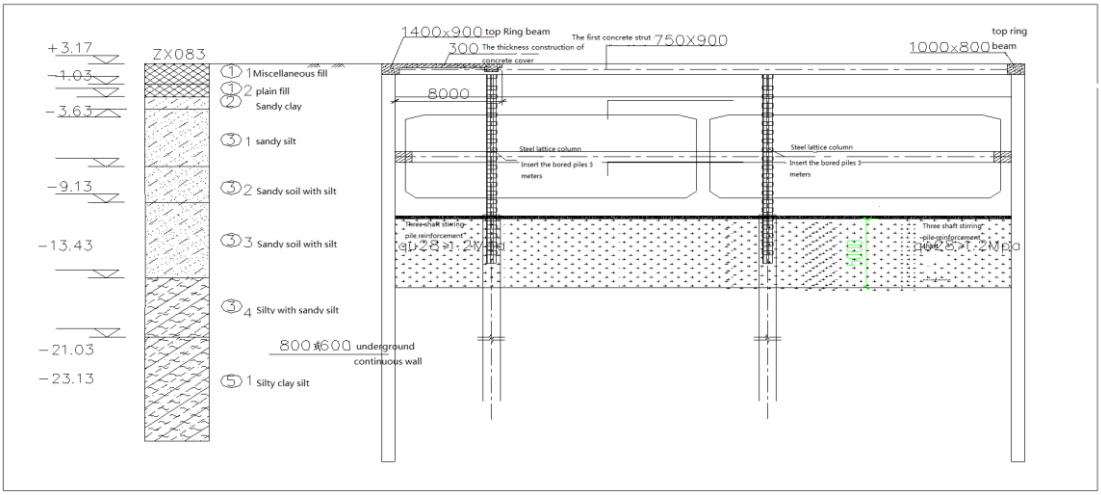

Fig. 1 Rainbow Road (mind of city road ~ workers road) section A geological profile

East from the existing metro line two Hangzhou station is about 20m, the end shaft excavation depth 19.30m, the retaining structure of the 800 thick underground continuous wall, the wall depth 41m.

On the west side of the workers road and workers River, river water supply workers' Concrete DN400, a electric power supply of 450 ×150 workers under the river.

1.3 STRUT STRUCTURE

Combined with the characteristics of the project, according to the principle of"economic, security, convenience of construction" , the foundation pit use the retaining structure scheme of underground continuous wall and inner strut o, buried section 30 to 34 underground continuous wall with thickness of 600mm and two concrete strut buried section 17b to 29 underground continuous the wall thickness is 800mm and three concrete strut, the bottom using high pressure jet grouting pile of bar reinforcement, reinforcement depth of pit bottom down 5m.

2 MONITORING SCHEME

2.1 MONITORING ITEMS AND ARRANGEMENT OF MEASURING POINT

According to the engineering excavation depth, environmental characteristics, physical and mechanical properties of soil layer foundation index and strut design scheme, scheme of deep foundation pit monitoring and measurement point layout, as shown in Table 1 and Figure 2

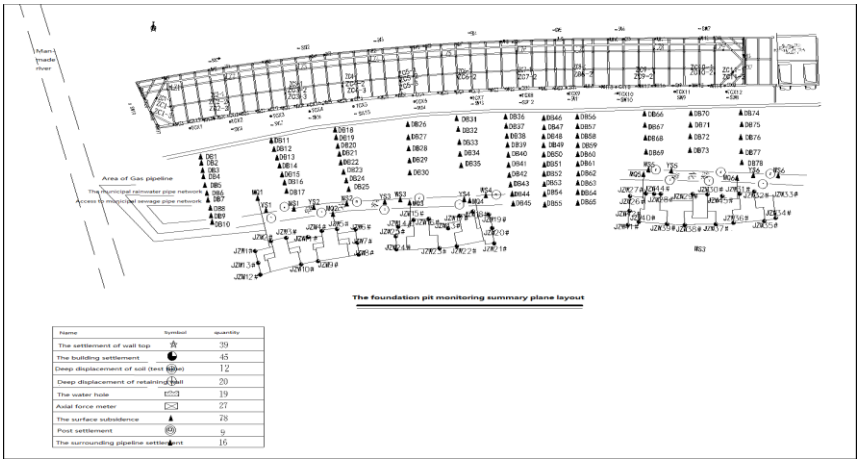

Fig. 2 Schematic diagram of monitoring points arrangement

Table 1 monitoring items, equipment, observation frequency and control standards list

Serial number	Monitoring project		measuring points number	Models and precision of testing equipment	Observation frequency	Control standards
1	Displacement monitoring	Monitoring of the wall top settlement	39Point	electronic level	During the excavation of foundation pit the 1time/day pouring bottom 1time/2day	Cumulative settlement 2.5cm Rate 3mm/d
2		Monitoring the surface subsidence	78Point	electronic level		Cumulative settlement 5.0cm Rate 3mm/d
3		Post settlement	3Point	electronic level		Cumulative settlement2.0cm Rate 3mm/d
4		The building settlement	54Point	electronic level	Beyond the excavation of foundation pit 1/3d During the excavation of foundation pit 1/d pouring bottom 1/2d	Cumulative settlement1.0cm Rate 2mm/d
5		Deep lateral displacement of retaining wall	20Root	CX-06C Type Slip inclinometer The sensitivity of the sensor : 0.02mm/8″	During the excavation of foundation pit the 2/d pouring bottom 1/d	Cumulative warning value 5.0cm Rate：3mm/d
6		Deep lateral displacement	12Root			
7	force monitori	Strut axial force	27group	frequency recorder	During the excavation of foundation pit 2/d pouring bottom 1/d	Warning value : 9000KN
8	Pipeline observation	Around pipeline settlement	18point	electronic level	During the excavation of foundation pit 1/d pouring bottom 1/2d	Cumulative settlement 3.0cm Rate 3mm/d
9	Water level monitoring	Groundwater level	19hole	Electronic water meter Precision：1cm	During the excavation of foundation pit the 1/d pouring bottom 1/d	The cumulative warning value：Rate：-500mm/d

2.2 MONITORING ALARM VALUE

According to the design requirements of the project and the relevant standard requirements, the project monitoring and warning values are as follows:

(1) Soil and wall accumulated the maximum horizontal displacement ±50mm, or horizontal displacement for three consecutive days over 3mm/ days;
(2) The warning value of the settlement of ground surface horizontal displacement and the largest settlement is ± 50mm ;
(3) The maximum settlement warning value of the wall top settlement is ±25mm;
(4) The maximum settlement warning value of surrounding buildings is ±10mm ;
(5) The maximum settlement of surrounding pipeline settlement warning value is ±30mm
(6) Strut axial force 9000kN
(7) The underground water level warning value one-day decline more than -500mm

3 ANALYSIS THE DATA OF STRUCTURE OF FOUNDATION PIT MONITORING

3.1 DEEP DISPLACEMENT LAW

3.1.1 INCLINOMETER EQUIPMENT AND PRINCIPLE

Horizontal displacement of deep soil by burying the inclinometer pipe inclinometer monitoring. The inclinometer pipe is the use of special PVC rigid pipe , buried outside the foundation pit. As inclinometer tube at the bottom is a fixed point, the point relative to the bottom end of the displacement is the horizontal displacement . The following test methods: inclinometer sensor alignment direction of the lateral displacement guide groove, slipped the inclinometer gently to bottom of pipe, stop a moment to make it stable and test its readings, reading a time after each enhance the inclinometer every 0.5 meter , until the mouth of pipe. Then rotated the inclinometer 180 degrees into the same on the guide groove, according to the above method to repeat the test a time, in order to eliminate the instrument error.

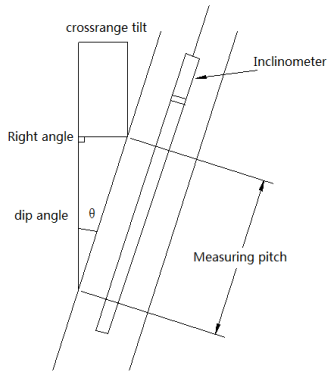

Fig. 4 principle diagram inclinometer

3.1.2 INCLINOMETER MONITORING RESULTS

Table 2 results of inclinometer monitoring

Hole number	CX1	CX2	CX3	CX4
The maximum displacement	38.58	41.16	44.71	36.59
Depth	7.0m	14.0m	6.0m	7.0m
Date of occurrence	13-12-17	13-12-4	13-12-17	13-12-4

Through the comparison of displacement monitoring alarm value, in the whole construction process, deep soil displacement does not exceed the alarm value.

3.1.3 ANALYSIS OF DATA

According to the result of soil horizontal displacement curve, can obtain the following results:

From the deep soil displacement curve can be seen, the soil displacement with depth increase the horizontal displacement increases gradually, until it reaches the peak lateral displacement in the interval (-6m__-10m). In the cx3 curve, the cumulative displacement of deep level (44.71mm, depth at -6.0m), is the engineering foundation pit of the strut structure of the maximum lateral displacement of wall during the construction.

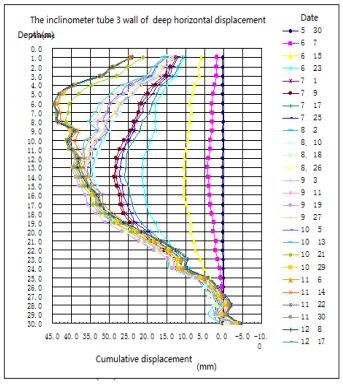

Figure 5 CX3 Horizontal displacement of deep soil duration curve

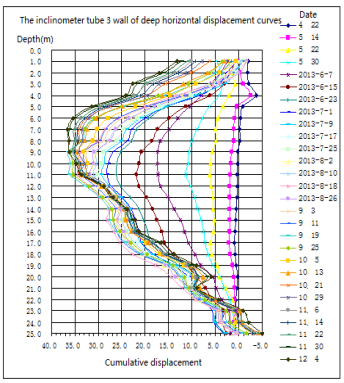

Figure 6 CX4 Horizontal displacement of deep soil duration curve

When the curve reaches the peak displacement, deep soil displacement decreased gradually along with the depth increasing lateral displacement, in this process, the displacement curve close to zero displacement, and reflects the positive displacement trend in some curve. This shows that when the depth increases, the soil displacement will reduce or stable at a fixed value.

During the construction process, deep soil displacement does not exceed the alarm value, the soil displacement in a safe state.

3.2 BUILDINGS AND PIPELINE SETTLEMENT
3.2.1 SETTLEMENT OBSERVATION RESULTS

(Fig. WH20, JZW2, DB4 point, YS5 sedimentation diagram)

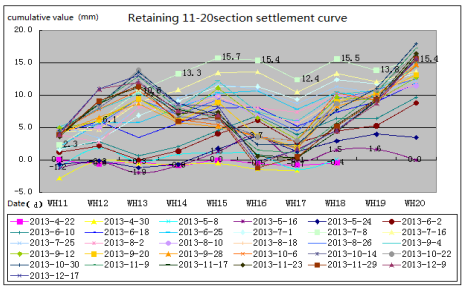

Fig. 9 fence settlement curve

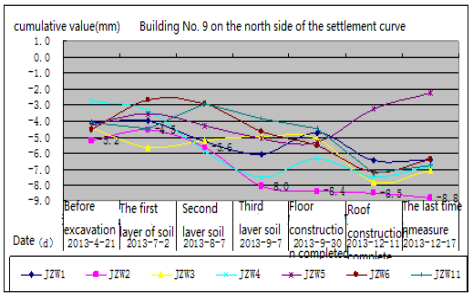

Figure 10 the surrounding buildings settlement

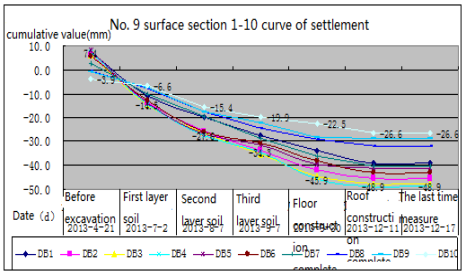

Figure 11 the surface settlement curve

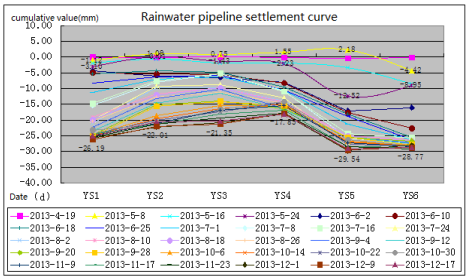

Fig. 12 rainwater pipe settling curve

3.2.2 ANALYSIS OF SETTLEMENT REGULARITY AND REASONS

(1)The settlement of retaining structure

In the process of foundation pit construction , settlement with the retaining structure construction process forward and increase gradually, cumulative subsidence quantity of WH20 test points (Figure 9) is 15.4mm, reach the maximum settlements of construction process, but still more than monitoring alarm value. Enclosure structure settlement did not increase with the construction time of growth, but with the change of the construction progress and change. As in the WH20 test points to achieve maximal settlement, is the time for the construction side of the roof construction, influence on the retaining structure is relatively large.

(2)The surrounding buildings settlement

The surrounding buildings, the maximum settlement is JZW2 measuring point (Figure 10), the cumulative subsidence quantity is -8.8mm, the settlement and the rate is normal , but not exceeding the design warning value (± 10mm). Foundation soil are the main factors that influence the settlement of buildings, mainly in the first and second layers of soil process, JZW2 measured settlement changes, and after the top plate and the bottom plate in the process of construction, building settlement is relatively small, show a steady trend.

(3)The ground surface settlement and the settlement of pipeline

In the process of pit excavation, the surrounding ground and pipeline accumulated settlement is obvious, located in 9 floor surface DB1-DB25 section, in the excavation of the first layer to the third layer of soil during the rate increased significantly, the cumulative values are between -5.2mm to -34.3mm. Through comprehensive analysis, due to the Mong Kok city an area surrounding the road backfill is loose, the cross section of the deep partial excavation caused increasing trend. By December 17, 2013, the cumulative maximum ground surface settlement for DB4 points of measurement, the settlement of -48.9mm, did not exceed the warning value design (±50mm), the maximum total settlement of pipeline for YS5 points of measurement, the accumulative settlement -29.1mm, did not exceed the alarm value design (±30mm).

CONCLUSION

(1)In the process of foundation pit construction, both the deep ground displacement or a settlement strut structure will change. So real-time monitoring to master dynamic construction, monitoring and analysis of the content, guiding the follow-up construction plays an important role in the development of the whole construction process.

(2)Began of foundation pit construction , for foundation pit soil after construction, construction to the floor as soon

as possible, to reduce the deformation caused by the accumulation of soil creep. This is more important for the soft soil area, prevent the creep of soil and soil caused by the creep damage on construction site.

(3)In the monitoring process, strut the settlement, displacement are controlled within a predetermined range, show that foundation pit construction is always safe, stable; adjacent roads, building (structure) has no substantial settlement.

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