Research on Deep Foundation Pit Excavation Based on Data Monitoring

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Abstract. The safety of foundation pit is related to the safety of surrounding buildings and roads, so it is necessary to closely observe the settlement around the excavation process. Based on the monitoring data during the excavation of the deep foundation pit project in a hospital in Guiyang, this paper studies the variation law of the excavation process of the deep foundation pit: If the excavation depth of the foundation pit is above 9 m, the key factor affecting the settlement is the surrounding shallow foundation, and the factor that has great influence on the settlement of the foundation pit below 9 m is the side length of the foundation pit; After the depth of the foundation pit reaches 15 m, the influence of the side length of the surrounding shallow foundation and the foundation pit on the settlement around the foundation pit will gradually disappear, and the settlement of the foundation pit will become stable at this time; Around the road settlement in the excavation depth of 12 m more obvious changes in the settlement area below 12 stable and less later changes; The change law of crown beam settlement and horizontal displacement of foundation pit tends to be consistent with the surrounding settlement.

1. Introduction

As the city enters the mature development, the space for the city to expand outward is decreasing, and the buildings inside the city are aging gradually, which requires the city to replan. The foundation depth of the general high-rise building is 1/15~1/12 [1] of the total building height. Cowland [2] research on surface settlement caused by trench forming process, it is found that the total variable caused by trench construction before excavation accounts for 40%~50% of the deformation. Huang Guanglong, Zhang Feng, Xu Hongzhong [3] applied other practical FBG sensors blue measurement of the internal force of the supporting beam in the foundation pit support structure. Clough. O'Rourke [4] studied the relationship between surface subsidence and trench depth, and obtained that the maximum surface subsidence caused by trench construction of ground connection wall under different geological conditions is about 0.15% of trench depth. Because this technology also takes into account the temperature effect, the data obtained is more accurate than the traditional monitoring method. This paper is based on the monitoring for deep foundation pits [5].

2. Calculation method of surface settlement

The influence range of foundation pit excavation on surface settlement is related to many factors [6]. For example, it depends on soil parameters, excavation depth of foundation pit H, soil entry of supporting structure, weak underlying layer and whether there is support and its construction.
conditions. Generally the range of settlement is about (1-4) H after supporting structure. At present, there are two methods for calculating surface subsidence: formation loss method and estimation method.

2.1. Formation loss method
This method uses the correlation between the corresponding area of formation movement and the lateral deformation of the surrounding (branch) retaining structure, and assumes the form of surface subsidence curve according to experience, so that the surface subsidence can be obtained from the known lateral deformation of the surrounding (branch) retaining structure.

2.2. Estimation method
Among these methods are space-time effect method, Perk method and stability factor method.

Time-space Effect: The viscoelastic finite element method can be used to consider the time effect, and the 3D finite element method can be used to consider the space effect. To determine the parameters of viscoelastic constitutive model, it can be fitted by triaxial shear creep test or single shear creep test results. This method is called the empirical estimation method of spatiotemporal effect if using the measured data of the foundation pit and the influence of these parameters on the deformation of the foundation pit are put forward by statistical analysis.

Peak method
Surface subsidence Eq. 1

\[ \delta = 10 \times K \times a \times H \]  

Eq: \( K \) - correction coefficient. With respect to the maintenance wall \( K = 0.3 \), the column type retaining wall \( K = 0.7 \) and the plate wall \( K = 1.0 \); \( H \) - depth of foundation pit \( a \) - the ratio of settlement to excavation depth in (%).

This method not only affects the geological factors, but also considers the influence of the stiffness and construction technology of the retaining structure. The calculation result of this method is more safe than the actual value and is only used for preliminary calculation.

Engineering practice has proved that there is a certain functional relationship between the safety factor of uplift and the maintenance structure, and between the maximum horizontal displacement of the maintenance structure and the maximum settlement of the surface outside the maintenance structure, so there is a certain functional relationship between the maximum settlement of the surface of the maintenance structure and the safety factor of the base uplift. Therefore, the \( \delta_{\text{Hmax}} \) and \( \delta_{\text{Vmax}} \) can be obtained by calculating the safety factor of the pit bottom uplift \( F_s \), according to their relation.

3. Analysis of foundation pit monitoring data

3.1. Settlement monitoring points
Monitoring network layout: The elevation reference network (point) of this project includes the settlement monitoring points of the building (construction) structure, the settlement monitoring points of the surrounding road surface, the settlement monitoring points at the top of the foundation pit to form a closed ring, or the formation of a node network composed of the attached route for leveling observation.

Monitoring point layout principle: The settlement monitoring points of the surrounding building (construction) are arranged on the construction (construction) corner and load-bearing column within the range of 2 times the depth of the excavation side line of the foundation pit, and 37 monitoring points are temporarily estimated to be set up; The settlement monitoring points at the top of the foundation pit are arranged along the top of the foundation pit for every 20 meters or so (the same position as the horizontal displacement monitoring points at the top of the foundation pit), and 17 monitoring points are temporarily estimated; The road around the foundation pit, the monitoring point of surface settlement should be set on the surface of the soil layer outside the supporting structure or on the flexible ground. The horizontal distance from the supporting structure should be within 0.2
times of the depth of the foundation pit. One monitoring point is arranged every 20 meters in the area 5-15 meters away from the side line of the foundation pit, and one row is arranged every 5 meters. It is estimated that 62 monitoring points are arranged temporarily Figure 1.

3.2. Monitoring data analysis
Analysis on Monitoring Data of Construction Settlement in Surrounding Area
In order to observe the influence of the excavation process on the surrounding settlement, the settlement of the surrounding buildings has been measured five times, and the five monitoring data are in different stages, all of which are the key stages that have a great influence on the building safety.

Figure 1. Layout of monitoring points

Figure 2. First cumulative settlement    Figure 3. Second cumulative settlement

Figure 4. Third cumulative settlement    Figure 5. Fourth cumulative settlement
As can be seen in the first monitoring. J19, J20 and J21 are far away from the foundation pit, showing a large uplift in the middle of the monitoring number, while J12, J13 and other points close to the settlement is more obvious (Figure 2). Showed in Data collected for the second time (Figure 3). The settlement of surrounding buildings is stable in the whole area, and the change trend is consistent with the first change trend. However, the settlement of J6 and J13 points is relatively obvious, both of which are the building corner near the foundation pit. The third monitoring is to excavate to the depth of 9m of the building. At this time, the influence of the excavation depth of the foundation pit on the surrounding buildings reaches the overall settlement (Figure 4). The fourth data collection is when the excavation reaches about 12m. At this time, the foundation pit support is completed, and the support system has strong constraints on the surrounding soil mass. However, due to the rainy season, the groundwater is relatively rich and the water level is high. So that the data collected in this stage shows that the buildings around the foundation pit have an upward trend (Figure 5). The fifth monitoring is that all supporting structures are completed. At this time, the whole area of soil around the foundation pit is stable, and the continuous drainage keeps the underground water of soil outside the foundation pit stable. Therefore, the whole system is in a relatively stable state at this stage. The other convenience is that the foundation pit has been excavated to a hard soil layer at this time (Figure 6).

3.3. Settlement of surrounding roads

In order to observe the influence of foundation pit excavation process on the surrounding settlement, the settlement of surrounding buildings has been measured five times, and the five monitoring data are in different stages, which are the key stages that have a significant impact on the construction safety.
In the first monitoring, it can be seen that the road monitoring point BDC12-BDC28 near the back of the foundation pit (shallow foundation position) shows obvious settlement, and the main road in the west of the foundation pit is slightly uplifted from BDC52, BDC54, BDC56, BDC58 and BDC60 far away from the foundation pit. This phenomenon is due to the settlement near the foundation pit and the inclination of the rigid body (Figure 7). With the continuous excavation of the foundation pit, the settlement of the surrounding buildings is synchronous with the settlement of the buildings, while in the west of the foundation pit there is only the main road. At this time, the settlement shows the overall settlement of all monitoring points, which shows the road settlement phenomenon (Figure 8). The results of the third monitoring show that there are relatively stable changes in each monitoring point, i.e. the settlement area is stable (Figure 9).

4. Summary
Based on the displacement changes of surrounding buildings, road settlement and the retaining structure of the crown beam of the foundation pit during the excavation of the foundation pit, the following conclusions are obtained: the influence of the shallow foundation around the foundation pit on the surrounding settlement of the foundation pit is greater than that of the surrounding deep foundation buildings; among the influencing factors of the foundation pit settlement, the shallow foundation around the foundation pit is the main influencing factor when the excavation depth of the foundation pit is more than 9 m, and the foundation pit is more than 15 below 9 The side length is the main influencing factor, the settlement of the foundation pit below 15m tends to be stable; the settlement of the surrounding road above 12m depth of the foundation pit is more obvious, and the settlement tends to converge after 12m depth.

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