Analysis and Research on Surface Settlement Characteristics in Super High-rise Building Construction

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Abstract: The volume of ground settlement tank of super high-rise building is equal to the volume of stratum loss, and the transverse ground settlement distribution approximately meets the Gaussian normal distribution in a certain range from the tunnel axis to both sides. The formula is used to describe the difference of surface subsidence trend caused by super-tall buildings in different strata by the width of settlement tank and the rate of stratum loss. However, the geology of different cities is often very different, and the setting of excavation parameters and surface settlement characteristics of super high-rise buildings are also different. Rock and soil mass is a natural medium with complex causes, and its deformation characteristics are very complex, so it is difficult to accurately calculate it theoretically. In practical work, the method of combining field observation with theoretical analysis is often used to monitor and analyze the surface deformation. According to the measured data in the construction process, this paper studies the characteristics of surface settlement during the construction of super high-rise building, and analyzes the progressive increase of surface settlement and the law of deformation distribution of this high-rise building. By comparing the theoretical calculated value with the measured value, the mechanism of surface subsidence is analyzed.

1. Introduction

When the underground excavation method is used for the construction of super high-rise buildings, the volume of the excavated rock and soil will generally be greater than that of the super high-rise buildings after completion. The difference between the two volumes is called stratum loss. The rock and soil around the super high-rise buildings will move and deform in the process of making up for the stratum loss. The surface settlement control requirements are strict, and the control standard of shield construction is generally + 10mm ~ - 30mm, so as to maximize the impact of shield tunneling on the surrounding environment [1-2]. The volume of ground settlement trough from the super high-rise building is equal to the volume of stratum loss, and the transverse ground settlement distribution approximately meets the Gaussian normal distribution in a certain range from the tunnel axis to both sides. The formula describes the difference of surface settlement trend caused by super high-rise buildings in different strata by the width of settlement trough and formation loss rate [3]. However, the geology of different cities is often very different, and the setting of excavation parameters and surface settlement characteristics of super high-rise buildings are also different. There are a wide range of black and gray soft soils in the upper part of the basin, mainly silt and mucky soil, with a thickness of more than 10m, with high water content, large void ratio, low strength, high compressibility and other properties, as well as poor engineering characteristics such as low permeability, thixotropy and rheology [4]. In innovative application, it is necessary to change the concept of support design in the past, establish unified support standards, establish a dynamic management system, and realize real-time monitoring of the whole process. Secondly, we should pay attention to the deformation of the support structure, so that the obtained data are accurate and reliable, and the construction scheme can be adjusted in time. In addition, the construction shall be carried out in strict accordance with the construction scheme. The setting position of support shall not be changed at will, and the setting distance, range and grading coefficient of reinforcement mesh shall not be changed at will. When the buried depth of super

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high-rise buildings is shallow and this movement and deformation reach a certain degree, it will be clearly reflected on the surface, forming observable surface settlement [5-6].

Surface subsidence is an important index that must be controlled in super high-rise building construction, especially in shallow-buried super high-rise building construction. Rock and soil mass is a natural medium with complex causes, and its deformation characteristics are very complex, so it is difficult to accurately calculate it theoretically. In practical work, the method of combining field observation with theoretical analysis is often used to monitor and analyze the surface deformation. When the super high-rise building and the section diameter are determined, the lateral settlement curve of the surface settlement tank is related to the stratum loss rate Vl and the width coefficient K of the settlement tank. The change of surface settlement is influenced by human factors such as supporting measures of super high-rise buildings and construction progress, and controlled by the deformation characteristics of rock and soil. Supervisors should cooperate with technicians to make full use of the ability of soil displacement control during excavation to avoid collision damage between supporting structures. After excavation, check and accept the site to avoid long-term exposure of the foundation pit, and check whether the supporting structures are safe and stable before backfilling [7].

2. Field monitoring

2.1. Measuring point setting and monitoring

In the actual construction, the process of super high-rise building construction is very complex and cumbersome. In the early stage, the soil or rock and soil are in the initial stress state, and its process will destroy the original equilibrium state, resulting in abnormal changes in the displacement field and stress field of soil or surrounding rock, resulting in adverse effects on the surrounding environment and structures. According to the elastic-plastic theory in the finite element, the boundary range of the finite element simulation model is mainly determined by the numerical calculation accuracy and the influence on the surrounding soil and nearby structures [8]. In fact, the wider the boundary range is, the more realistic the calculated result is, but it will be limited by the requirements of computer performance and the length of time. If the boundary value is relatively small, there will be inevitable errors in the calculation conclusion. According to the topography of super high-rise buildings, a total of 11 construction surface settlement observation points are set, and the specific locations are shown in Figure 1. The buried depth of the monitored location is about 6m ~ 7m, as shown in Figure 2. The maximum difference in relative elevation between the measuring points is about 1.3m.

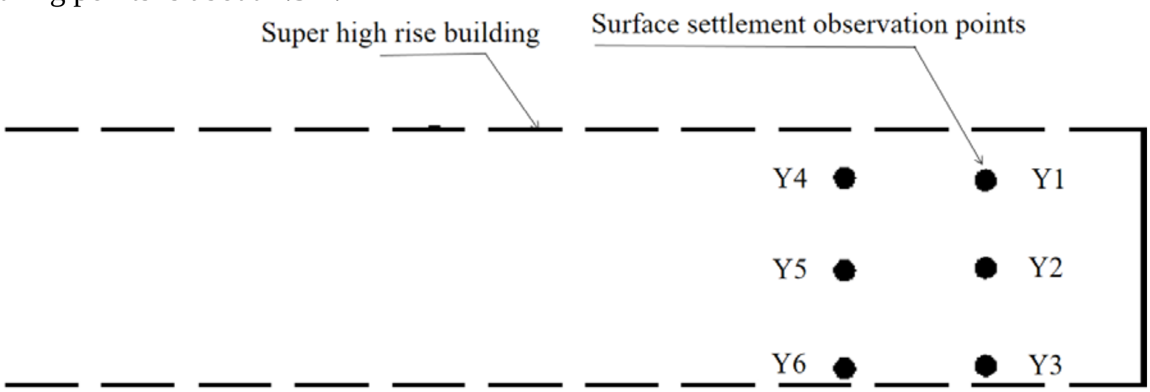

Figure 1 Schematic diagram of plane layout of surface settlement monitoring points

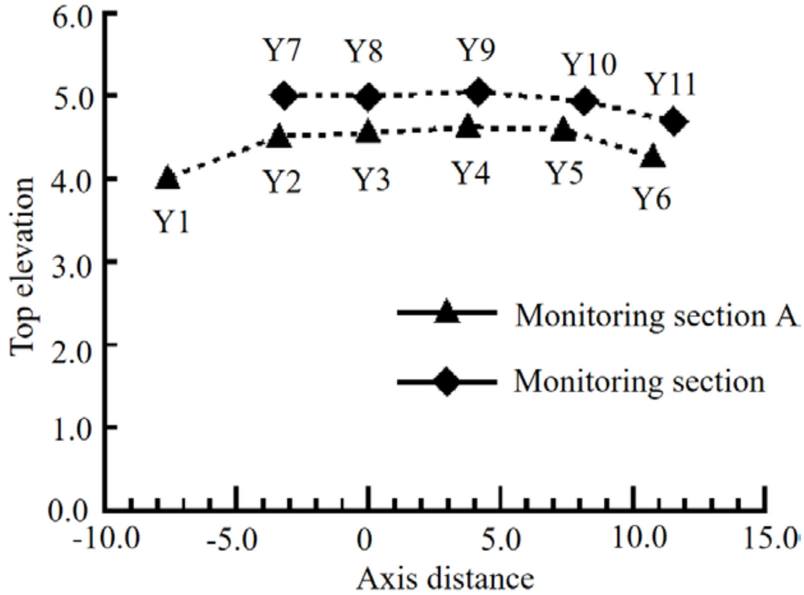

Figure 2 Schematic diagram of relative elevation of surface subsidence monitoring points

During the construction of super high-rise buildings, the surface settlement is observed by high-precision total station, and the observation period is determined according to the deformation rate, which is generally 4 days to 10 days. The construction of super high-rise building is regarded as a discontinuous process, in which ABAQUS unit is used to kill material simulation, the unit distance of equipment excavation is proportional to the width of lining segment, and at the same time, the equipment unit, prefabricated segment and reserved void unit are activated to simulate the process. The top of the numerical model is a free boundary, the bottom is a fixed boundary, and the side faces are set with normal constraints to limit the deformation. Shield surface settlement is mainly divided into horizontal and vertical settlement monitoring, with the settlement control value of -33~15 mm, that is, the settlement control value of 33mm and the uplift control value of 15 mm. The layout principle is as follows

① Longitudinal surface monitoring points: a monitoring point is arranged every 5 rings (1 ring is 1.2 m) along the center line of the main tunnel line.

② Transverse surface monitoring points: within 120m of shield starting and receiving, a cross section is arranged every 15 rings, and the rest is a monitoring cross section for 66 rings. Taking the axis of the shield section as the center line, a measuring point is arranged outward every 2.3m, 3.6m and 5m, and 7~9 points are arranged on both sides.

The monitoring work closely follows the progress of shield tunneling. According to the situation of shield tunneling, the distance from ≤20m before and after excavation is kept twice every day, and the distance from ≤50m before and after excavation is kept every 2d/ time.

2.2. Surface subsidence change

The settlement of each measuring point shows a relatively consistent regularity. When the excavation is close to the surface, the settlement of the face will gradually increase, and the face will gradually appear when it is close to the surface. The maximum value is reached within a few days after the connection, and then the surface deformation gradually tends to be stable. According to the engineering data and the measured surface settlement data of each section, combined with the fitting results, the surface settlement data are sorted as follows, as shown in Table 1.

Due to the influence of site conditions and other factors, the number of measuring points of each section is 3 ~ 6, and the correlation coefficient of most section fitting curves is more than 0.83, which has high reliability. According to the shield propulsion record report, the shield machine also has a warped head, and the small thickness of the top overburden should be one of the main reasons for this situation. The overbreak and disturbance of shield during curve propulsion and snake correction will also cause stratum loss. In view of the large surface settlement, it is suggested that when the shield reaches and crosses the main target, the propulsion speed and excavated volume should be taken as the main control indicators. When the shield tail is separated from the inner lining, the excavated volume and synchronous grouting volume should be taken as the main control indicators, and the deformation value of the nearby surface should be fed back to the shield propulsion control room in time to adjust the relevant construction parameters in time! Achieve information construction.

Table 1 Fitting parameters of surface settlement tank

Construction method	Section	Initial support thickness a/mm	Excavation area A/m2	Excavation width b/m	Buried depth z0/m	Formation loss rate Vl/%	Width of settling tank i/m
Up-down step method	Right line 11-11	240	34.15	6.2	18.7	1.335	9.026
	Right line 1-1	240	33.28	6.2	18.82	1.178	4.457
CRD method	Right line 6-6	360	56.91	8.84	18.53	0.63	14.29
	Right line 8-8	320	47.75	7.52	17.15	0.425	13.25
	Left line 3-3	320	57.55	8.43	17.56	0.185	9.542

3. Analysis of construction monitoring data of super high-rise building

3.1. Analysis of surface subsidence data

Because of the large cohesive force of soft soil, which has a certain "space-time effect", it will take some time to fill the building gap, so the ground loss settlement will not end until the shield tail is out for some time, and then it is mainly consolidation settlement. The anchor supporting structure in soil layer of super high-rise building is characterized by high stability and high technical requirements, which can improve the stability of the whole super deep foundation pit structure. In the design of super high-rise building, it is necessary to determine the depth and specific location of drilling holes, use anchor drill to drill holes, and then pour cement slurry into the holes. Through the analysis of the measured data of ground deformation in a large number of engineering examples, many scholars roughly divided the ground displacement into three stages according to the curve of ground settlement change, namely, the first stage, the ground deformation before the arrival of shield machine. In the second stage, the ground deformation when the shield arrived. In the third stage, the deformation of shield when it passes through the ground. In the fourth stage, the ground deformation is instantaneous after the shield passes through. In the fifth stage, the surface is subsequently consolidated and deformed. Construction personnel are required to make full preparations before construction, including hydrological survey and survey setting-out, and must ensure the accuracy of drilling position, so as to avoid large deviation between design conditions and actual depth and position. Secondly, it is required to clear the surrounding obstacles, and construction is not allowed when there are obstacles around. Until the terminal shaft is removed. There are many functions of shield in dangerous road, which are briefly described as follows: playing the role of external support, excavating soil layer under the shield shell and installing lining gun. The shell can support the interior, and if necessary, the internal structure of the super high-rise building can be divided into several small spaces by clapboards, which can increase the rigidity of the shield and make the operation more convenient. Because there is no internal support at the tail of shield, lining can be assembled under the cover of shield.

3.2. Relationship between tunneling parameters and settlement

Combined with the longitudinal settlement of sdc111 ~ sdc131 measuring points, the setting of tunneling parameters during this period is analyzed.

① The theoretical calculation formula of frontal equilibrium earth pressure is

$$P = K_0 \gamma h \quad (1)$$

Where: P is the equilibrium earth pressure; γ Is the average weight of soil mass; H is the buried depth of the tunnel center; K0 is the lateral static equilibrium pressure coefficient.

② The stratum loss settlement value S3 of measuring points sdc111 ~ sdc131 is large, which may be due to the large amount of excavated soil or the small amount of synchronous grouting.

The calculation formula of theoretical excavated quantity of each ring is

$$V_{\pm} = m\pi D^2 L / 4 \quad (2)$$

Where: m is the coefficient of looseness; D is the excavation diameter of cutter head; L is the ring width, taken as 1.3m. V soil = (1.07 ~ 1.15) × π/4 × six point four seven two × 1.2 = 45.9m3/ring, and the excavated volume of each ring is 45m3, which is within the reasonable range of theoretical excavated volume.

During excavation, the amount of synchronous grouting is 5M3 / ring, and the filling rate of building gap is 175%. Due to overbreak or grouting loss of shield, the filling rate of 175% is too small, resulting in more than 10mm stratum loss and settlement S3. In actual operation, in order to reduce the stratum loss and settlement after the shield tail is detached, the filling rate can be increased to 200% and the timeliness of synchronous grouting can be guaranteed. In this project, the construction area around the station is flat. During the hydrological survey, it is found that the construction area is close to the riverbed, part of the rock and soil is loose, there are many soft layers, and the surface layer contains clay and silt. This part of the soft foundation must be removed before construction. Because the soil in soft foundation has large pores and high water content, it will affect the stability of ultra deep foundation pit. Consolidation and secondary consolidation settlement will continue to occur for a long time. According to previous engineering experience, most of the subsequent consolidation deformation of the ground only accounts for a small part of the total ground deformation. For soft plastic and fluid plastic clays with large sensitivity and porosity, the secondary consolidation settlement often lasts for more than several years, and the proportion in the total settlement may also be relatively high, up to about 34%.

4. Conclusions

The change of surface settlement during the construction of super high-rise building is analyzed and discussed. The field monitoring results show that the surface subsidence is obviously affected by the construction. Peck settlement curve can be used to fit the loss settlement, consolidation settlement or long-term settlement considering consolidation settlement. With the tunneling of shield machine, the width of settlement tank for stratum loss and stratum loss rate increase continuously, and the width of consolidation settlement tank increases with the consolidation of disturbed soil. When the excavation face is about 20m away from the monitoring section, the surface settlement is obvious. The surface settlement gradually increases with the approach of excavation face, and reaches the maximum after excavation, and then the surface deformation gradually stabilizes. The maximum surface settlement is less than the control value, and the tunneling parameters are set reasonably. After the shield tail emerges, synchronous grouting shall be carried out in time, and the grouting filling rate shall be appropriately increased to 200% to reduce the stratum loss and settlement after the shield tail emerges. Shield construction in soft soil area should minimize stratum disturbance to reduce consolidation settlement. Uneven distribution of in-situ rock and soil mass will also cause deviation between calculated value and actual deformation, so in practical application, it is necessary to consider the influence of soil and rock distribution state of in-situ rock and soil mass, structural plane and other factors.

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