Analysis of deformation law of an airport foundation pit monitoring in loess area

Shuli Guo [1, a], Kongfeng Wei [1, b] ,and Weiqiang Wu [2, c]

[1]Gansu Construction Supervision Co., Ltd., Lanzhou 730000, China;

[2]China Construction Eighth Engineering Division Co., Ltd., Shanghai 200135, China.

[a] 83565697@qq.com, [b] 253047918@qq.com, [c] 68444235@qq.com

Abstract. This paper takes an airport foundation pit project in northwest loess area as the research object, and introduces the key method technology of support, construction and monitoring of this foundation pit project. The scope of this foundation pit project is widely distributed, there are no buildings in the surrounding area, and there is less restriction on the construction space, so the GRF01 green assembled support method of Slope release with soil nail wall is adopted, which controls the deformation of the foundation pit well and at the same time, plays the role of green environmental protection and reduces the cost. The analysis of the pit monitoring data shows that the pit engineering support design scheme effectively controls the deformation of the pit, and all monitoring data did not reach the alarm value, which ensures the safety of pit excavation and in-pit operation, and achieves the dual goals of economy and environmental protection. It can provide reference for the design and construction of similar large-scale foundation pit excavation and support in loess area.

Keywords: foundation pit; Support method; monitoring.

1. Introduction

With the rapid development of China's urban construction and the diversification of transportation modes, the way of traveling by airplane has greatly improved the efficiency of life, in which the airport pit project is one of the important constructions to ensure the safety of the airport. Airport pit project is different from ordinary pit project, which has the characteristics of wide distribution of pit range, more excavation depth, more complex geological distribution. At present, most scholars at home and abroad focus on the research of foundation pit engineering mainly in the dense urban building areas [1-10], and less research on the large-scale foundation pit engineering of airports. This paper takes the background of a large-scale foundation pit expansion project of an airport in Northwest China as the background, briefly introduces the support method adopted in this foundation pit project, and analyzes the monitoring data of the foundation pit to verify the reasonableness of the support method, which meets the requirements of design and environment.

2. Project Overview

2.1 Overview of the pit and surrounding environment

This airport foundation pit project directly interfaces with expressways and intercity rapid railways on the west and north sides, and the south and east sides are the main roads of the city. Given the numerous pits, broad scope, diverse elevations, and complex excavation conditions, the total amount of excavation volume is substantial, about 596,000 cubic meters. The site's surface elevation ranges from 1934.52 to 1944.91 meters. The terrain within the site is relatively flat, characterized by gentle, expansive undulations with minimal fluctuation. The overall inclination moves from north-east to south-west. The foundation pit safety classification is Tier II, with some sections classified as Tier I. It mainly consists of four “finger corridor” areas (A, B, C, D) and one terminal building area E, with a total of five partitions, as shown in Fig. 1, of which the total area of the terminal building pit is 75,000 square meters.

The construction site of this project has no underground pipelines, and field flat for the site have been completed. Existing apron and airport runway to the west of the perimeter of the construction site. on the southwest perimeter site stands our fecund T1 and T2 terminals that have already been established and are in operation; on the south side of the perimeter site is a white space awaiting development; on the east side of the perimeter site is a series of highways that have been constructed and partially blank areas undergoing development. The predominant means of transportation to and from the site is through the airport expressway, provincial highway.

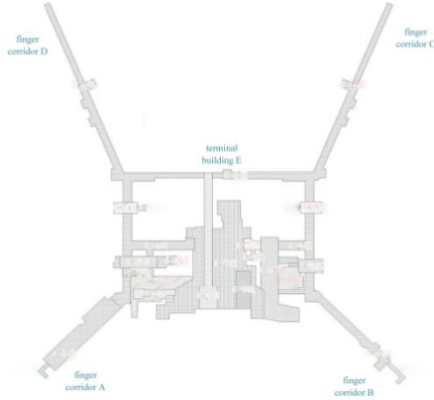

Fig. 1 Foundation pit zoning map

2.2 Engineering Geology and Hydrogeology Overvier

The area of the new T3 terminal building is a Class II (medium) self-weighted wet subsidence loess site, which is mainly distributed in the surface layer of the existing ground. the thickness of top layer loess in Area A and Area D is 2~5m, and the thickness of top layer loess in Area B, Area C and Area E are all less than 2m.Area B and E are processed by replacement filling, after digging out all Q4 (2-1) loess-like soil, use non-corrosive high-quality soil (content of soluble salt is less than 0.3%) to fill in layers of rolling, backfill soil shall not contain tree roots, grass roots, garbage, etc., backfill thickness of each layer is 50cm, and the compaction coefficient of the layered compaction is not less than 0.96. See Figure 2 for a map of the distribution of wet-sagged loess replacement.

The distribution range of the site pit is large, and the stratum of each area is different, and the stratum is roughly distributed from top to bottom as loess, loess-like chalk, fine sand, gravel, chalk, and gravel. The groundwater of the site is submerged groundwater, and the depth of the stable groundwater level of the site is 25.2-30.1m, with an annual variation of 1.0-2.0m.

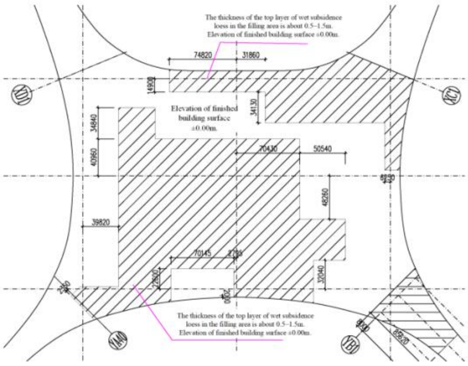

Fig. 2 Distribution of Wet Trapped Loess Replacement

2.3 Overview of pit support structures

The support form of this project adopts "GRF01 green assembled support", as shown in Fig.3. GRF01 technology belongs to the green assembled soil nail wall support technology, which is based on the principle of soil nail wall support and improves the design of the slope protection layer. Based on the principle of soil nail wall support, it improves the design of slope protection surface layer.GRF01 surface layer adopts green assembly recyclable surface layer instead of shotcrete surface layer, the surface layer connects the anchors (soil nails) into a whole through connecting components, and the support system plays a protective role for the slope surface. The typical section diagram of step-slope and soil nailing wall support is shown in Figure 4:

Fig. 3 GRF01 Support Schematic

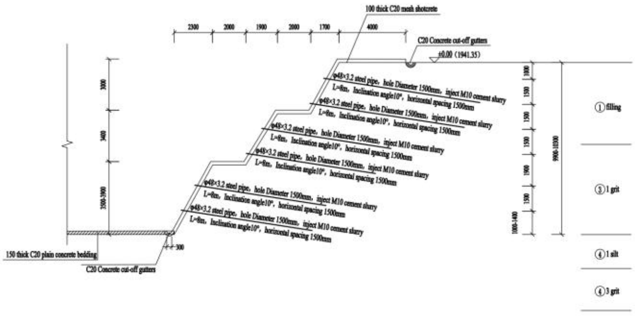

Fig. 4 Step-slope with soil nail wall support

3. Pit monitoring program

3.1 Monitoring content

Due to the excavation of the foundation pit, the displacement of the support structure will be the main reflection of the displacement caused by the surrounding ground, roads and buildings, so it is especially important to obtain the relationship between the displacement change of the supporting structure and the excavation depth of the foundation pit through monitoring. The monitoring object of this project is the pit support structure and the environment around the pit. The monitoring of foundation pit supporting structure is mainly the monitoring of horizontal displacement and vertical displacement of the top of the slope of supporting structure; the monitoring of surrounding environment mainly includes the monitoring of surrounding soil, submerged water level inside and outside the pit, neighboring buildings and pipeline facilities.

3.2 Layout of monitoring points

A typical layout of pit monitoring points is shown in the profile in Figure 5 In the figure, M denotes the ground settlement monitoring point, T denotes the soil obliquity monitoring point, and P denotes the monitoring point of the sinking & bumping and displacement at the top of slope. Note: The buried depth of the soil inclined pipe outside the pit: the buried depth of the inclined pipe after pouring piles is the same as the buried depth of the pile bottom, and the buried depth of the inclined pipe at the top of the slope of the rest of the slope rate method is 16m.

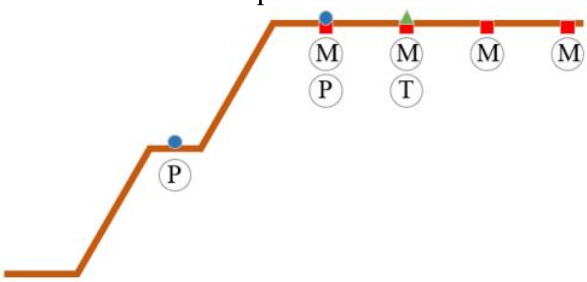

Fig. 5 Section of pit monitoring point arrangement method

The arrangement of pit monitoring points mainly includes: ground settlement measurement point M: 27 monitoring sections, soil slope point T: 38 measurement points, slope top sinking and bumping and displacement monitoring point P: 61 measurement points. Set up permanent monitoring base point and working monitoring base point. The permanent base point is set outside the pit, at a distance of 30 meters and at a location with good visibility; the working base point is set around the pit, at a stable and easy-to-observe location.the arrangement of the monitoring points in the E area of the terminal building is shown in Figure 6.

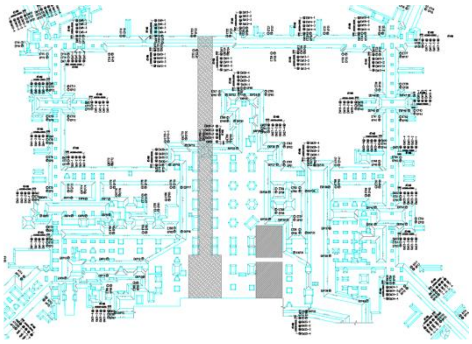

Fig. 6 Layout of monitoring points in Area E

4. Analysis of monitoring data

4.1 Analysis of monitoring results of horizontal displacement of the top of the support structure

Eleven typical monitoring points, EP67, EP68, EP69, EP69-1, EP70, EP70-1, EP71, EP79, EP80, EP82, and EP83, were selected for analysis, and the time-range curve of horizontal displacement at each monitoring point is shown in Figure 7.

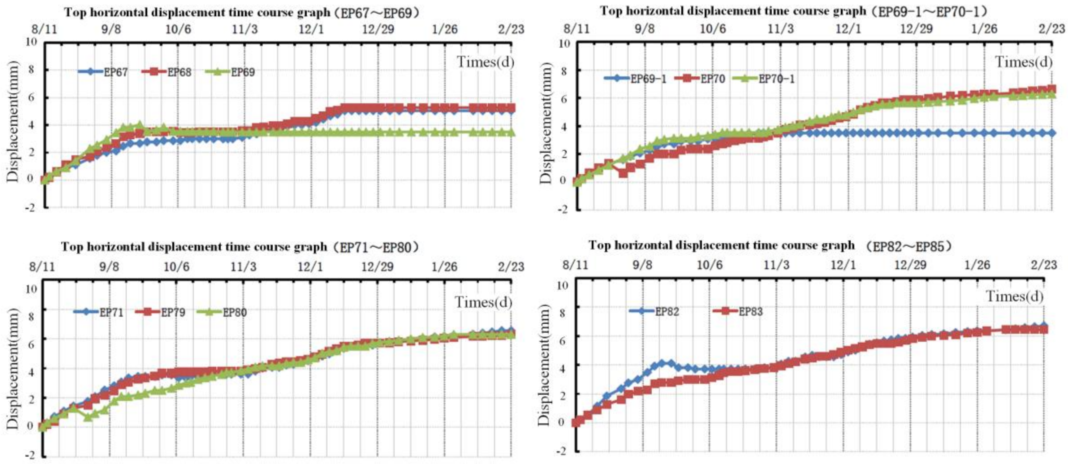

Fig. 7 Time course of horizontal displacement at the top of the feature monitoring point

As can be seen from the above figure, with the excavation of the foundation pit, the horizontal displacement of the top of the support structure is almost entirely in an increasing trend, and a small number of monitoring points show a decreasing and then increasing trend during the excavation of the foundation pit. Comparing the monitoring point locations, it is found that the monitoring point locations with this special trend are all in the position of the “Yang Angle”, which may be caused by uneven earth excavation on both sides of the “Yang Angle”, and may also be caused by the error due to the measurement. After the earth excavation was completed on September 28, the displacement time curve of the monitoring point grew slowly, and the slope of the curve was almost zero from mid-October to the end of October, at which time the maximum displacement value was about 4.2mm, indicating that the change of the surrounding earth pressure caused by the excavation of the foundation pit needed to be stabilized after a period of time. After November 3, with the construction of the internal structure of the pit (pit bedding pouring, raft construction, main body and internal pit operation), the horizontal displacement of the top of the support structure gradually increased, and the construction of the bedding and raft was completed on December 29, and then the displacement continued to increase slowly, and the maximum displacement on February 23 was about 6.7mm, Some of the unchanged monitoring points were due to the failure of monitoring points during the construction process. According to the size of the extreme values of these monitoring points, it can be seen that there is not much difference in the displacement values, which is because there is no additional load around any of the monitoring points of this pit.

4.2 Analysis of monitoring results of vertical displacement at the top of the support structure

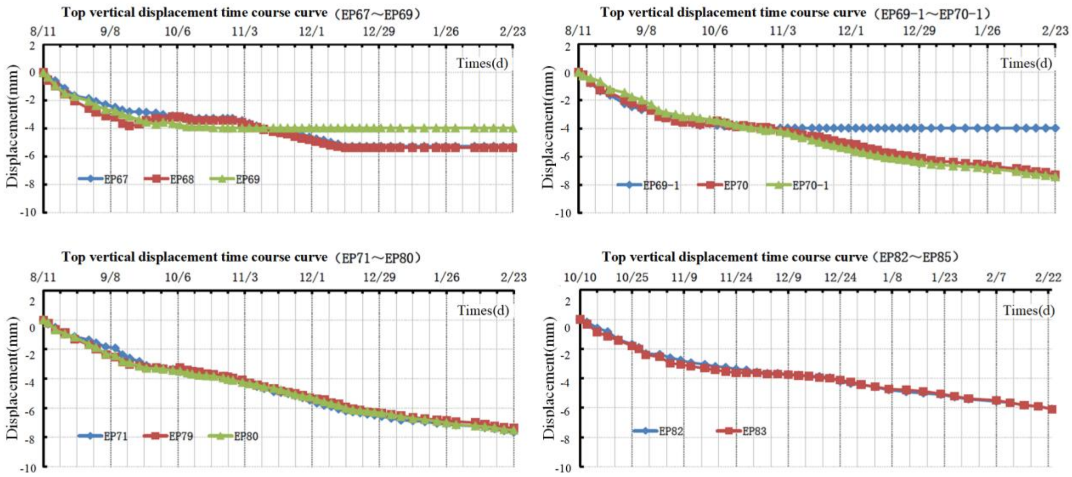

Fig. 8 Time course of vertical displacement at the top of the feature monitoring point

As can be seen from the above figure 8, with the gradual excavation of the pit, the vertical displacement of the top of the support structure gradually decreased, and after the earth excavation was completed on September 28, the rate of descent became slow, and the rate of change was almost zero between October 6 and November 3, at which time the maximum displacement value of each monitoring point was about -4.1mm. After November 3, with the construction of the internal structure of the pit, the vertical displacement of the top of the support structure continued to decrease, and the maximum displacement value was about -7.8mm on February 23. Comparison of displacement changes during earth excavation and structural construction shows that earth excavation affects displacement to a greater extent than structural construction. Some of the measurement points in the figure are failing over the entire monitoring range, so it fails to show the proper trend in the figure, but it is inferred from the nearby measuring points and the overall trend that the failed measuring points have the same trend with other measuring points in the vertical displacement.

4.3 Analysis of monitoring results of horizontal displacement at depth of the support structure

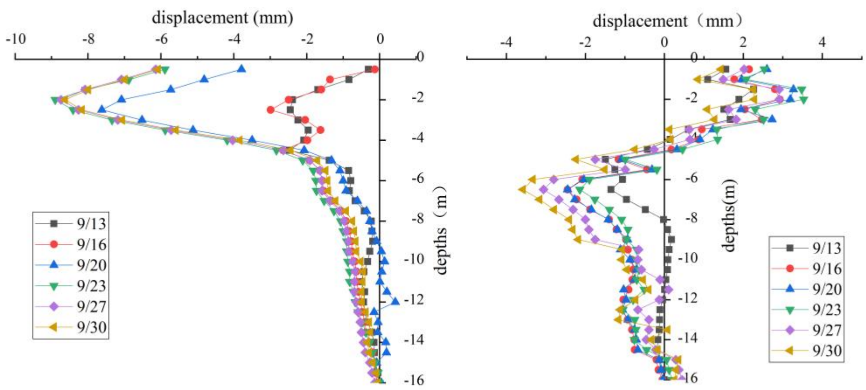

Fig. 9 Deep horizontal displacement profile at feature monitoring points

According to the monitoring results of the two characteristic monitoring points of ET69 and ET70, the deep horizontal displacement change curve is plotted, as in Figure 9. With the excavation of the pit, the horizontal displacement of the deep structure gradually increases. The monitoring point ET70 shows negative displacement at almost all depths, and the maximum horizontal displacement occurs at -2m depth, which is about -8.9mm. The displacements at monitoring point ET69 are all positive above depth -4m, and below depth -4m, the displacements are all negative. After the excavation of the foundation pit, the maximum value of horizontal displacement appeared at the depth of -6.5m on September 30, which was about -3.6mm. Overall, the horizontal displacement of the deeper layer varied more than that of the shallower layer, and with the increase of the depth, the horizontal displacement showed a general trend of increasing and then decreasing, and the place where the extreme value appeared was changed according to the difference of the stress state of the monitoring point.

5. Summary

This paper takes an airport pit project in Northwest China as an example, and analyzes the construction monitoring results of the pit in the case of adopting the green assembly support method of GRF01, and the following conclusions and insights can be obtained:

(1)Through the monitoring of the foundation pit support structure in the excavation and construction stage of the pit, the maximum values of horizontal displacement and vertical displacement at the top of the support structure are 6.7mm and -7.8mm respectively, and the deep horizontal displacement is located in the shallow layer at -2m, with the maximum value of -8.9mm. All of them do not reach the monitoring alarm value, which is in line with the requirements of the foundation pit safety.

(2)For large pits with no buildings around, GRF01 green assembly support can be used, which can effectively control the horizontal and vertical displacements at the top of the pit as well as the deep horizontal displacements, guaranteeing the safety of the pit operation and at the same time playing the role of economy and environmental protection.

(3)Pit monitoring work is very important for pit excavation and pit operation, and is the basic method of pit informationization. The deformation will be controlled to a safe range, and when the alarm value occurs, it can be detected in time and the corresponding measures can be adopted to ensure that the project will be carried out safely and on schedule.

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