Application of Comprehensive Rectification Method in Rectification of Buildings

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Abstract. This year, there are two ways to rectify buildings: forced landing and jacking up. The method of landing is to increase the settlement of the smaller side of the building, and the method of landing is the digging soil method, the irrigation method, the pile loading method, etc. the jacking method is on the basis of the stable foundation settlement, and the upper structure or foundation is raised on the larger side of the building so that the building will be leveled back, and the jacking method has static pressure pile top. Lifting method, lime pile lifting method, high pressure jet pile jacking method, etc. But in practice, a kind of rectification method cannot meet the purpose of building rectification. It needs two or more rectification methods to achieve the goal. This method of simultaneous application of two or more rectification methods on the same building is called the comprehensive rectification method. In this paper, some common rectifying methods are introduced. At the same time, the application of the comprehensive rectification method in engineering is explained in the background of practical engineerings.

1 Introduction

In recent years, with the rapid development of China's economy, construction engineering has also developed rapidly, but the rapid development of construction engineering has also brought a lot of engineering quality problems. Various reasons such as bad geological phenomena, inadequate surveying technology, poor construction quality, improper use and maintenance, design defects, and even natural disasters have caused the settlement and tilt of the building, which has greatly affected people's production, life and safety. It also caused trouble for the protection of ancient buildings. Therefore, people are paying more and more attention to the rectification of buildings^[2].

Abroad, research on the technology of tilt correction of buildings started earlier. At the beginning of the 20th century, the Catholic Church of Mexico City tilted, at which time an "underground pumping method" was proposed. But because the construction technology was not perfect at the time, the operation was very difficult and had to be abandoned. This is the first thought enlightenment of building reinforcement. With ideological enlightenment, the technology of reinforcement and rectification has entered a rapid development, the most famous of which is the Leaning Tower of Pisa, Italy, which has undergone anti-settling, tower reinforcement, sedimentation by stacking, additional anchors, dumping, digging, Many measures, after 11 years of rectification work before and after, the tower top was restored to about 4.5m away from the original position. The commission announced that the Leaning Tower of Pisa would not be in danger of

collapse for 300 years. [1]The most representative method of the lifting and tilting method is the Transcanian barn of Canada, which uses a concrete pier under the foundation on the side of the settlement and uses a jack and a support system to lift the warehouse to gradually tilt the barn.

Compared with the development of foreign reinforcement and rectification technology, the development of China's reinforcement and rectification technology has begun relatively late. Since the 1980s, domestic scholars have started to study the reinforcement and rectification technology of buildings and have achieved fruitful results. . [3]On the basis of the "underground pumping method", Professor Liu Dezu proposed the "correction method for ground stress". Professor Ruan Weiwen and others have developed jacking correction technology. Professor Tang Yeqing invented the method of radiating water to take out soil and correct the tilt. There are also very practical methods such as slope tilt correction method, anchor static pressure pile tilt correction method, earth digging and irrigation water correction method, etc., which have achieved good results in building tilt correction projects.

However, in recent years, due to the diversity of tilting reasons, in practice, one tilting method cannot meet the needs of building tilting, and two or more tilting methods must be used simultaneously. Therefore, the comprehensive tilting method has become more and more important.

2 The main rectification methods of buildings

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There are three main ways to correct the tilt of buildings.

2.1. Forced landing

Take certain measures to sink the smaller settlement side of the building and reduce or eliminate the settlement difference from the larger settlement side to achieve the purpose of rectification. Compared with the lifting and tilting method, this method is less risky, but has strict requirements on the settlement rate. Common forced landing correction methods include:

2.1.1 Digging method

Excavation method mainly refers to digging out an appropriate amount of soil on the smaller settlement side of the building to achieve its purpose of tilting. The excavation amount V is calculated according to the following formula, U on the right-hand side.

$$V=1/2 (S_{\max}F) \quad (1)$$

$S_{\max}$ — Settlement required for foundation correction, m;

F —Base area, m^2

The stress relief method, the digging and irrigating method, and the radiating well watering and digging method are all types of digging methods.

2.1.2 Water treatment method

Water treatment methods can be divided into precipitation treatment methods and immersion treatment methods.

The method of precipitation treatment is to lower the groundwater level in the foundation soil on the side where the settlement of the building is small, increase the effective stress of the soil body, and cause it to produce consolidation settlement; To make it wet and deformed, this method is mainly targeted at collapsible loess areas.

2.1.3 Pile foundation unloading method

Pile foundation unloading method can be divided into pile tip unloading method, pile body unloading method, pile top unloading method and cap unloading method according to different unloading parts. The pile tip unloading method is to pull out the soil below the pile tip on the smaller settlement side to produce settlement; the pile body settlement method is to fill the soil on the pile side with water and dig the soil to reduce the friction on the pile side to make it Settlement occurs; the pile top unloading method generally uses the pile top to intercept the pile to reduce the bearing capacity of the pile foundation and cause the settlement; the cap unloading method is to dig the soil below the platform or saw off the bottom of the platform but the building generates settlement.

2.1.4 Load correction method

Load correction is to artificially change the load of the original building. By loading or pressing on the side where the building settlement is small, the foundation is settled to change the uneven settlement of the original building foundation. The tilt correction method is suitable for silt, soil, and collapsible loess.

2.2 Jacking

The jacking method is to jack up the superstructure or foundation on the side where the existing building has a larger settlement and stabilize the foundation settlement so that the existing building structure is leveled.

2.2.1 Tilting method of anchor rod static pressure pile

Anchor static pressure pile tilting method is to embed the anchor rod on the basis of the larger settlement side of the building, and use a jack to press the prefabricated pile into the foundation soil. Materials continue to settle, so as to achieve the purpose of rectification.

2.2.2 Expansion agent tilting method

Expansion agent tilting method refers to that the high-pressure cement slurry or chemical slurry is used to infuse the expansion agent into the foundation soil on the side where the settlement of the building is relatively large. This method has less damage to the environment, but because of its limited elevation, it is only suitable for small tilt correction projects.

2.2.3 Lifting underpinning system

The underpinning system jacking method is mainly to set jacking points under the column or wall of the bottom floor of the building on the opposite side of the slope. The arrangement and number of jacking points are determined by the jacking force and the superstructure load. Commonly used methods are the jacking method of underpinning beams and the bottom jacking method of foundation beams.

2.3 Comprehensive tilt correction method

Comprehensive tilt correction method refers to the use of two or more tilt correction methods to achieve the purpose of tilt correction.

2.3.1 Comprehensive rectification method for lifting and landing

The comprehensive rectification method of jacking and forced descending is to use piles to lift the existing building on the side where the settlement is large to prevent it from continuing to settle, so as to reduce the settlement difference between the two sides of the

building. Digging, immersing in water, pressurizing and other methods for forced landing and correction.

2.3.2 Comprehensive forced landing correction

When a forced landing method fails to achieve the desired correction effect, two or more methods can be used to force the existing building to perform a correction. However, this method has higher requirements for the detection of forced descent speed.

2.3.3 Unloading traction correction method

The existing building is unloaded first and then towed by a towing device. Straighten the building by traction. This method is suitable for projects with soft soil but strong stiffness of the building itself, such as water towers and granaries

3 Tilting project case

3.1 Project Overview

A high-rise residential building has 1 basement floor, 27 floors above ground, a total height of 76.850m, a weight of about 1,5341.6t, and an indoor and outdoor height difference of 0.450m. The structural form is a cast-in-situ shear wall structure, and the foundation form is a reinforced concrete raft foundation with a raft thickness of 1m and a buried depth of about 4m. The CFG composite foundation is used for the foundation treatment under the raft. After the main construction of the high-rise residential building was completed, it was found that the residential building was inclined, which caused difficulties in installing an elevator. The measured maximum settlement at the northwest corner of the building is 114.6mm. The slope of the building towards the north is 6.71 ‰ and the slope of the building towards the west is 2.8 ‰. According to the Code for Design of Building Foundations, the overall slope The allowable value of 2.5 ‰ specified in the code has been exceeded, and the settlement of the building has not yet stabilized.

Table 1. Parameters of each soil layer

Floor	Soil layer	Thickness[m]	Deformation modulus[MPa]
1	Artificial filling	3.5~7.4	—
2	Silty clay	2.5~3.2	3.34
3	Silty clay	3.3~4.7	4.60
4	Silty clay	2.6~4.7	5.15
5	Silty clay	1.7~3.4	6.25

6	Silty clay	2.3~3.6	5.89
7	Silty clay	6.0~8.3	6.49
8	Gravel	16.0~3.2	27.50
9	Silty clay	1.5~2.1	7.53
10	Coarse sand	2.2~3.8	27.00

Floor	Internal angle of friction [°]	Adhesion[kPa]
1	—	—
2	7.8	17.4
3	12.8	27.3
4	15.2	37.4
5	19.4	49.1
6	19.0	45.8
7	20.7	51.1
8	35.8	—
9	21.8	53.9
10	32.7	—

3.2 Cause analysis of settlement

According to the "Code for Design of Building Foundations", the main bearing layer is the soil layer 2. The calculated total settlement of the foundation is 157mm, which indicates that the properties of the foundation soil of the building are poor, which is one of the reasons for the settlement. During the excavation of the underground garage in the later period, the construction unit arbitrarily expanded the excavation range and excavation depth, exposed the soil body, reduced lateral restraints, and caused uneven settlement of the building.

3.3 Correction plan

Because the building is a high-rise building, the tonnage is extremely large, if it is too difficult to adopt the jacking method, the rectification plan considers the forced landing rectification method. Because the building is in an unstable state, and there are many causes for settlement, the plan chooses a comprehensive

tilt correction method that comprehensively uses the anti-tilt and forced landing tilt correction methods.

As the building is in an unstable state, anti-tilt reinforcement should be carried out first to prevent the settlement on the larger side from intensifying. Anti-tilt reinforcement methods generally use piles. For this building, if the commonly used anchored static pressure piles are used, because the raft is thick, penetrating the raft will increase the difficulty of construction, and the building has a large weight and the strength of the static pressure piles is not sufficient. The large number is not conducive to construction, so the anchor static pressure pile is not suitable for the project; if the cast-in pile is used to analyze the surrounding environment of the building, it can be seen that the construction building is closer to the surrounding buildings, the cast-in pile construction space is required, and the site The space cannot meet its construction requirements. If it is far away from the building, the anti-tilt effect is not obvious, so the cast-in-place pile is not suitable for the project. Comprehensive consideration, it is more appropriate to choose high-pressure rotary jet pile. ^[4]Deploy piles on the northwest side of the building and perform anti-tilt treatment.

After the tilt is stopped, the building should be tilted and strengthened. First of all, a manhole is arranged on the east and south sides of the building, and the building's own weight is used to gradually load. It is the discharge of pore water in the soil, which is helpful for the building to tilt back to that side. The law forcedly descended and rectified the building, breaking the original soil balance and forcing it to settle. Thirdly, the method of excavating trenches is used to achieve the purpose of releasing stress. When excavating trenches on the side with less settlement, a free end is formed on one side of the soil body, which relieves the horizontal stress constraint and causes vertical deformation of the soil body. After the above-mentioned tilt correction and reinforcement measures, the tilt effect cannot be achieved, and the tilt sand method can be used to further tilt correction.

After the reclining and strengthening of the project, the slope rate was reduced to less than 2.0 %, and the deformation of the building tended to be stable

4 Outlook

Several conclusions can be drawn from the example project:

Before carrying out reclining construction on an existing building, it is necessary to carry out anti-tilt treatment to prevent its possible continued settlement from adversely affecting the reclining construction.

Because existing buildings are generally reinforced and tilted in the first floor or underground space, the construction site is small, and the use of large machinery to strengthen and correct the slope often cannot be successfully constructed, and it is necessary to develop a method of strengthening and correcting the slope for small sites. High-pressure jet grouting pile is a suitable

method of strengthening and correcting tilt, which has the advantages of large bearing capacity, convenient forming, simple construction, flexible site application, and high cost performance. Online references will be linked to their original source, only if possible. To enable this linking extra care should be taken when preparing reference lists.

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