Application of active anti-floating in underground structure based on automatic drainage system

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Abstract. With the continuous rapid development of China's economy and the rapid progress of urbanization, the development and utilization of urban underground space continues to develop downward, and the problem of anti-floating of underground structures is increasingly prominent. Passive anti-floating methods will continue to increase engineering costs while increasing structural resistance. The anti-float method reduces the base buoyancy while reducing the project cost accordingly. Through "plus" and "minus" comparative study, the advantages of the active anti-floating method for underground structures based on automatic drainage systems are highlighted, combined with specific engineering practices and application effects. To further confirm the advantages of the active anti-floating method for underground structures based on automatic drainage systems.

1. Introduction

With the continuous and rapid development of China's economy and the rapid progress of urbanization, the contradiction between urban land resources and geographic scale has become increasingly prominent. It is no longer possible to meet the demand for land in urban development by relying solely on high-rise buildings to expand space.

Academician Qian Qihu[1] pointed out that the orderly, rational, comprehensive, and efficient development and utilization of urban underground space resources is the most effective and realistic way to solve the "urban syndrome" based on the above contradictions. "from heaven the earth" also promoted the three-dimensional development of urban space.

However, with the continuous development of underground space downward and deeper, the anti-floating problem of the building base caused by the groundwater level difference has become increasingly prominent, especially in the areas of high groundwater level in southern coastal cities. In addition, the development time of underground space in my country is relatively short, and there are certain shortcomings in theoretical research and design methods, which are prone to serious problems in project construction: such as the buoyancy of the raised groundwater level in the podium of the Dreamland Commercial and Residential Quarter in Haikou City due to heavy rain, which lead to the two-story basement box under construction rises to the ground up to 4.5 m[2]. And the upper arch of the basement of the tower and podium of Yongfeng Building in Foshan, Guangdong is 213 mm[3]; the maximum uplift of the basement of Shenzhen Baoan China Travel Hotel is 160 mm[4]; the basement of a sloping building in Shenzhen floats up 160 mm[5]. A storage pool in Shenzhen also has unevenly
floated up, with one side floating about 0.5m and the other side floating up to 1.8m[6]. In addition, there have also been many engineering accidents in Taiwan area of building underground structure anti-floating failure. The underground structure floats up as a whole or the bottom plate raised, causing the bottom plate and the beam-column joints to crack and damage, causing serious consequences[7].

In the past engineering practice, the traditional anti-floating design of underground structures is mainly an "additive" method, which offsets the buoyancy of the base by continuously increasing the resistance of the structure. It is also called a passive anti-floating method, such as counterweight method, anti-floating anchor method, anti-floating pile method; but as the underground structure is developed deeper and larger, this method will lead to a substantial increase in engineering economy and time cost.

In recent years, the anti-floating design of underground structures has begun to try the "reduction" method, which reduces the buoyancy of the base by draining groundwater through the drainage system. It is also called the active anti-floating method. This method saves anti-floating structural measures and can greatly reduce engineering economy and time costs. Dr. Qin Yawei[8] took the construction of a large underground parking garage in Shenzhen as the research background, and systematically comprehensively studied the methods of drainage, decompression and anti-floating of underground structures from seven aspects including construction period and life cycle cost. Gan Quan et al.[9] used FLAC3D software to analyze the anti-floatation of the basement of the WuJiao West Bank residential project, discussed the principle of the anti-floating design of the basement by the decompression method, and studied the application of the decompression technology in the actual project. Scope of application and main features. Cao Hong et al.[10, 11] studied the concept and application of anti-floating and anti-floating of underground structures, and introduced a method of using drainage corridors for anti-floating of slope underground structures. Guo Hai et al.[12] and Dai Guang Wei et al.[13] introduced the construction technology of the basement structure floor hydrophobic layer in combination with different projects.

2. Project overview
The Walton 1275 (Hechang Center) project is located on the west side of the main road around the island and the northwest side of the International Convention and Exhibition Center in Xiamen City, Fujian Province. The total construction area is about 323,400 square meters, of which the above-ground construction area is about 178,800 square meters, and the upper part consists of 3 buildings of 46 square meters. Small high-rise houses 1, 2, 3# 14 floors, 6 106~146m super high-rise houses 4, 5# 32 floors, 6, 9# 38 floors, and 7, 8# 45 floors.

Figure 1. Project renderings

The basement area of the project is about 144,600 square meters. The topography of the project is high in the west and low in the east. The height difference between east and west is about 12.7 meters. The anti-floating problem of basement floor is particularly prominent.
3. Design scheme

3.1 Overall plan
The original design of the basement floor of Walton 1275 (Hechang Center) project is to use anti floating anchor rod for anti floating. In order to meet the anti floating requirements, a large number of anchor rods need to be constructed, which has a long operation period and high cost. Especially, during the construction period, the noise is large and the duration is long, which has a great impact on the surrounding environment. In order to reduce the impact on the life of the surrounding residents, after demonstration, a new pressure reducing technology of the filter layer at the bottom of the plate is selected. The technology filters the groundwater through the filter layer, and then the water is induced into the S-shaped drain plate by the guide plate, and the groundwater is discharged into the drainage culvert by using the groundwater pressure. Through the calculation of water pressure, the opening height of municipal pipeline is calculated. Due to the water pressure, the water is automatically discharged from the water conveyance culvert to the municipal pipeline, so as to reduce the buoyancy of groundwater and achieve the active anti floating effect, thus eliminating a large number of anchor rod construction, at the same time, speeding up the construction progress and saving the project cost.

![Figure 2. Project topography diagram](image)

3.2 Hydrophobic plate design
From the bottom to the top, the materials are geotextile, gravel layer, induction plate, double-layer "s" plastic drainage plate, film, cushion and floor.

![Figure 3. Sectional view of drainage plate](image)

3.3 Design of catchment culvert
The water collecting culvert is mainly composed of 0.8m * 1.8m water collecting culvert, 0.8 * 1.2m drainage shaft, anti backflow duckbill valve and municipal water collecting well.
4. Construction technology of automatic drainage system

4.1. Key processes
According to the characteristics of the automatic drainage system, the key procedures are as follows: ① After the tank is inspected, the base layer is covered with geotextile, and 10cm thick sandstone is laid on the geotextile as a water filter layer. ② Wrap the induction board with geotextile and place it on the sand. Place an S-shaped hydrophobic board wrapped with geotextile on the induction board. The water is drained through the S-shaped drainage board and covered with a film. The film and the film must be tightly connected. And pour the cushion. ③ The drainage system is connected to the drainage culvert, and the interface is tightly sealed. ④ Calculate the opening height of the municipal pipeline based on the water pressure and the building's own anti-floating ability, and install the reverse flow valve (to prevent the municipal water from flowing back).

4.2. Detailed process
The detailed process can be described as follows:
(1) Site leveling: According to the elevation of the drawings, the site leveling is performed manually.
(2) Geotextile laying: Fully spread with geotextile (200g/m2), and tape at the junction of geotextile to avoid loopholes.
(3) Installation of induction board: Use geotextile to wrap the induction board without any loopholes; after the wrapping is completed, lay it according to the drawing distance (radiation range is 2m from the left and right of the induction board).
(4) Installation of the double-layer "S"-shaped plastic drainage board: Lay the double-layer "S"-shaped plastic drainage board together and densely wrapped with geotextile, and placed on the induction board; when encountering lintels, use galvanized square steel Make the bridge to avoid the impact of the stress on the performance of the drainage board.
(5) Film laying: Use film for full coverage, and adhesive tape at the junction; prevent concrete from infiltrating the induction board and double-layer "S" plastic drainage board, blocking them, resulting in reduced hydrophobic performance.
(6) Cushion pouring: Carry out the cushion pouring according to the drawings, and pay attention to the protection of the finished product during the cushion pouring process to avoid damage to the drainage system.
(7) Catchment culvert construction and valve installation: While constructing the outdoor wall of the basement, set a catchment culvert on the side of low terrain and close to the municipal pipeline. Connect all underground drainage slabs to the catchment culvert to ensure that the water is collected here. Open the municipal pipeline, and set a reverse flow valve at the opening to ensure that municipal water does not flow back into the culvert.

5. Conclusion
We draw the conclusions as follow:
(1) The Walton 1275 (Hechang Center) project has been completed for more than one year and has been delivered to the owner. No phenomenon caused by insufficient anti-floating has been found; and the property draws water from the catchment culvert for community green irrigation to achieve energy saving Water saving and environmental protection.
(2) The construction of the automatic drainage system only takes one week. Compared with the original design of anti-floating anchor rod technology, the automatic drainage system is simple and quick to install, the construction period is short, and the impact of noise on the surrounding environment is reduced.
(3) Taking the Walton project as an example, the original design cost of anchor rod construction is about 28 million yuan, and the construction cost of automatic drainage system is about 4 million yuan, that is 1/7 of the cost of anti-floating anchor rod. Replaced by automatic drainage system Anti-floating anchor rod can save about 24 million yuan in cost.
With the development of society, competition in the real estate industry has become increasingly fierce, and the requirements for cost, construction period and environmental protection have become more and more stringent. Under the conditions of high groundwater level, the application of automatic drainage system in underground structure engineering meets the needs of anti-floating function and it can reduce the project cost, shorten the construction period, and realize energy saving, water saving and environmental protection. It has a strong promotion.

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