The development course of foundation engineering

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Abstract

From ancient times to the present, the towering building from the ground, the beach can not afford to build high-rise, which fully demonstrates the importance foundation for buildings and structures, foundation engineering discipline of importance is self-evident. Is based on the building under various load transfer to the foundation of entity structure, foundation engineering is one of the oldest engineering technology and young applied science, among them, as an important part of the foundation engineering, pile foundation, raft foundation and box foundation, deep foundation and underground continuous wall based on form of the main play an incomparable role.

Keywords

Pile foundation; Raft; Box foundation; Deep foundation; Underground continuous wall foundation

1. Introduction

As early as more than 10000 years ago, the ancient people created their own foundation technology.Such as marshes lay stakes, the build huts to avoid beast attack, 7000 years ago the Xi'an Banpo village sites also dug large stakes.The Dujiangyan irrigation project, the world-famous Great Wall, Sui Dynasty in the South and the North Canal, the Yellow River levee, the arch bridge with a Zhao Zhoushi and many magnificent palace temples, towering stand upright towers throughout the country, for the foundation firmly, are still safe and sound despite the numerous strong winds.Such as the road built in the Qin dynasty, the hidden gold vertebral subgrade compaction method was used; now traditional foundation processing methods commonly used are lime pile, dust, slag and tile layer and shake the sand cushion and so on. These are the model of the application of basic engineering technology in ancient China, but because of the level of development of productivity at that time was not refined into a scientific theory.

Foundation engineering discipline based on the theory of soil mechanics began in the 18th century industrial revolution in Europe. Large-scale urban construction and water conservancy, the building of the railway facing many soil mechanics and related problems, greatly promoted the emergence and development of the theory of soil mechanics. In 1773, Kulun, a French scholar, proposed the famous formula of the shear strength of the sand, and created the theory of sliding soil pressure of retaining wall. In 1869, the British scholar Lan Jin put forward the theory of earth pressure on retaining wall in another way, which effectively promoted the development of soil strength theory. In addition, 1885, French scholar Bhusan Niesk proposed elastic half space surface vertical concentrated force should force and deformation of the theoretical solution. In 1922, Sweden Phelan Neuse proposed stability analysis method; in 1925, Terzaghi American scholars concluded the achievements and discussed the basic theory and method of soil mechanics and foundation engineering, published the first monograph of local mechanics, these classical theories and methods are still the theoretical and practical.

2. The development course of pile foundation

As a kind of old foundation, pile foundation has been widely used form as early as 10000 years ago, such as stakes. Before the cement come out, it can only use the natural materials to make the pile, like

wood and stone pile. Beijing Yuhe Bridge, Xi'an Dam Bridge, the ancient city wall of Nanjing and Shanghai Longhua tower and so on are typical of China's ancient pile. Since the middle of the nineteenth Century, due to the emergence and development of cement industry, reinforced concrete began to widely used in construction engineering, so there was concrete piles and reinforced concrete piles. At the beginning of the concrete strength and steel bar strength is low, the theory of reinforced concrete has not been established, and then the type of reinforced concrete pile is also relatively simple. In 1920s, especially after the Second World War, the large-scale construction of bridges, railways and highways greatly promoted the development of pile foundation theory and construction methods. Because of its high bearing capacity, good stability, small settlement stability, small settlement deformation, strong seismic capacity, and it can adapt to various complex geological conditions, it has been widely used. Pile foundation is mainly used to bear the vertical compressive load outside, still in bridge engineering, port engineering, offshore oil platform, high-rise buildings and high-rise, retaining structures, earthquake resistant engineering structures and special soil foundation such as frozen soil, expansive soil to resist the lateral earth pressure, wave force, wind, earthquake force, braking force, frost heaving force, swelling force of horizontal and vertical pullout load, press into piles and pile for bored pile and precast piles, super long piles and pile with large diameter in two categories.

2.1 Pouring pile and prefabricated pile

Pouring pile includes artificial dig hole pile and mechanical drilling pile two categories. Pouring pile directly develops into the hole where the pile is designed and then below the hole the reinforcement cage and then poured concrete. As a large diameter bored pile, the manual hole digging pile has been published in 1893 in the United States. So far, it has more than 100 years. Bored pile come out after the advent of artificial digging pile in the early 1940s, with the successful development of high power drilling machine. With the world economic recovery and development after the Second World War, high-rise, high-rise buildings and heavy structures continue to be built, and the vast majority have used the bored pile. Bored pile began to flourish in the world, its dosage increased year by year. The bored pile in our country began in the early 1960s, initially, as a bridge and port construction foundation, and then gradually applied to large cities of high-rise buildings and heavy buildings. Pouring pile has the following characteristics:

(1)Pouring piles can be used in different strata;

The length of pile can be changed according to the change of the stress layer, and the pile is not required to be cut off;

The pouring pile can effectively save the steel, because there is no need to configure the reinforcing bar when the pouring pile is only subjected to axial pressure;

The pile has big bearing capacity when using large diameter drilling;

Compared with the precast pile, the cost of filling pile is lower than the precast pile in general.

Precast pile can not only be prefabricated at the construction site, but also can be manufactured in a factory, and then transported to the construction site. Precast piles can be steel pile or precast concrete pile. Prefabricated piles can be set in place by hammering, vibration, static pressure or rotating.Precast reinforced concrete pile structure durable, according to needs to be made into different sizes of cross section and length, bear larger vertical load and construction hammer blow stress, and not affected by groundwater and wet change. It is in a wide range of applications in building foundation. In recent years, with the continuous development of China's economic construction, suitable for heavy duty workshop, high-rise buildings and large bridge engineering, precast pile construction technology and machinery and equipment unceasing progress and renewal, experience design is also getting more and more rich and mature. Precast piles have the following characteristics:

The bearing capacity of precast pile is high, and the soft soil layer can be squeezed in the process of the construction of the prefabricated pile into the soil layer, which can greatly improve the bearing capacity;

The quality of precast piles is easy to be guaranteed and convenient for inspection;

Precast pile construction is relatively simple in the water;

The density of precast pile is large, and it has strong corrosion resistance;

The construction process of precast pile is relatively simple, so it has high construction efficiency.

2.2 Super long pile and large diameter pile

In recent years, with the development and improvement of high-rise buildings and large bridge engineering, and construction technology, the application range of the pile foundation also continues to expand, many types of piles, especially large diameter piles and super long clothes, the engineering practice also contributed to the pile foundation of theory research and practical application of continuous development and progress. In these buildings of high, heavy, and the settlement control requirements, when pile caps, number of piles and pile diameter can not be increased by design or economic requirements limit, only increasing the pile length way to improve pile bearing capacity and to control the settlement. The use of super long pile with high bearing capacity is inevitable. However, the existing theoretical analysis and design can not reflect the bearing behavior of super long pile.

At present, there is no clear definition of long pile, generally considered that the ratio of length to diameter is more than 50, that is, long pile, and pile diameter greater than 800mm of the pile is large diameter pile. Large diameter pile does not occur the overall shear failure under the load, and the soil from the compressor to play a leading role. With the load increasing, pile bottom soil produced volume compression and downward radiation shear, which ranked excavated volume enough to accommodate the sinking of the volume of the pile end, and will not lead to lateral extrusion formation leading to the pile end above the level of the continuous shear sliding surface. At present the pile foundation develop to large diameter piles and micro piles, small diameter pile accounts for the proportion is very small, a long history of study and application of small diameter pile, design method is relatively mature, bearing capacity of pile foundation in the current specification determination in small diameter pile considering. The performance of large diameter pile is different from that of small and medium diameter pile, and the standard is only modified by the experience of large diameter pile. It is a kind of estimation method, and it has no qualitative and quantitative research in theory.

3. Raft foundation and box foundation

3.1 Raft foundation

When the load of building or the upper structure is too large, the column in the cross foundation beam can not meet the foundation bearing force or although it can meet the requirements, the basal spacing is small, or the need to strengthen the foundation stiffness, it can consider the use of raft foundation, which is under the column cross beam foundation all the floor even together, the formation of raft foundation, also called the raft foundation. It not only can be used for wall, and also can be used for the column. Raft foundation has simple construction, good rigidity foundation and good seismic performance. And it can increase the bearing capacity of the foundation and regulate the buildings uneven settlement. As a large area foundation, according to the principle of overall stability to determine the bearing capacity of foundation. When the building standard width of a room size is not big, or a smaller grid size and on the basis of the stiffness requirements are not very high, make it into a thickness of reinforced concrete flat plate in order to facilitate the construction, it's that the flat plate raft foundation, board if there is a quantity, it becomes the beam slab or ribbed raft foundation. The stiffness of raft foundation is very large, so it can effectively adjust the uneven settlement of the building, especially in combination with the basement, to improve the bearing capacity of the foundation is very favorable. Raft foundations are generally considered in the following situations:

The cross strip foundation can not meet the requirement of the allowable deformation of the building and the bearing capacity of the foundation;

When the column spacing of the building is smaller, and the column load is large, base are must be connected into a whole in order to meet the requirements of the bearing capacity of the foundation.

Under the action of wind load and earthquake load, the foundation has sufficient rigidity and stability.

3.2 Box foundation

Box foundation is a spatial integral structure consisted of roof, floor, wall. It is made of reinforced concrete pouring. Part of the space can combine the use function of building design into the basement and underground equipment layer; with large stiffness and integrity, which can effectively regulating foundation uneven settlement. Because it has a greater depth of the soil and the soil has good embedded solid and compensation effect on it, so it is currently widely used in high-rise building foundation types with good anti seismic property and compensation.

Due to the design of box foundation is far more complex than the general basis, reasonable design and calculation should be considering the geological conditions of the construction site, construction method and the actual requirements, and to take proper account of the foundation and the superstructure interaction and mutual influence of adjacent buildings. The design content should include two major parts of the foundation design and the foundation structure design, specific contents are following:

Foundation calculation: bearing capacity calculation, foundation settlement calculation and lateral tilt check.

Base reaction calculation: including caused the foundation reaction by the axial load and longitudinal bending.

Foundation internal force calculation: the influence of the upper structure stiffness should be considered when calculating the internal force of the box foundation, and the whole bending and local bending should be considered simultaneously.

Base strength checking: foundation strength calculation should be separately floor oblique section shear strength checking, floor anti punching shear strength checking, interior and exterior wall shear checking entrance lintel section checking calculation and so on.

4. Deep well foundation and underground continuous wall

4.1 Deep well foundation

As early as in ancient times, due to the need of life and the development of productivity, the Xia Dynasty people has mastered the technology dug wells, then western countries used open caisson to construct bridges after the 19th century. Open caisson is a band edge foot shaft shaped structure creation, it uses manual or mechanical means to clear the rock in the hole, with the help of gravity or add pressure or other measures to overcome the wall friction resistance by section sinking to the design elevation, pouring concrete bottom sealing and packing hole, becoming the foundation of the building. Generally speaking, the shape of caisson sinking shaft is made of steel reinforced concrete structures and materials. When construct, lay sand cushion, set bearing chock, making the first caisson, including the possibility of some internal partitions, and digging in the shaft within the next, while digging edge row of mud, caisson hollowing out of the ground, shaft sunk by self-weight, so to product, take a long, sink to joint processing until the design elevation. Then pour the concrete to cover bottom, pour concrete floor, and constitute a whole underground structures.

Characteristics of the open caisson is buried depth and strong integrity, good stability, with large bearing area and it can bear large vertical and horizontal loads of open caisson, It is the most suitable to sink in the impermeable soil, so easily to control the caisson sinking direction, to avoid tilt. Generally, it can be given priority use of open caisson technology when in the following conditions:

The upper load is large, the bearing capacity of the foundation soil is insufficient, and there is a better bearing layer under a certain depth, and it is more economical and reasonable compared with other basic schemes;

In the mountain rivers, although the soil is better, but scour a lot, or the river has a larger gravel pile foundation construction;

The rock surface is flat and thin, but the water is deep, and it is difficult to expand the foundation pit of the foundation pit.

4.2 Underground continuous wall

Underground continuous wall excavation technology originated in Europe, it is according to the methods of concrete pouring under mud and water well drilling and oil drilling to develop. Milan in Italy, first used the construction of underground continuous wall mud in 1950 years, This technology was spread in western developed countries and the former Soviet Union popularized in 1950s~1960s. In the late 1950s, it was introduced into our country. At present, underground continuous wall in Japan is the most developed, it has completed a total of the underground continuous wall with more than 1500 million m2, in recent years the average annual completion of 0.6 to 0.8 million m2. Now, the countries such as Italy, France, Germany, the UK and Mexico are at the forefront of underground continuous wall technology. Underground continuous wall is a effective technology in underground engineering and deep foundation construction, the general refers to use the various mechanical dredging, with mud dado, to dig trench in the ground which is narrow and deep, and in the placement of appropriate materials formed together with seepage, retaining and bearing weight function, continuous underground wall.

Every country in the world firstly applied the application of underground continuous wall to the water conservancy and hydropower, and then extended to the construction, municipal, transportation, railways and other departments. In the early development, underground continuous wall only was used as a construction under horizontal load of the retaining wall and diaphragm wall. Now, engineering takes underground continuous wall as the main structure or at least as a part of the main structure to directly bear the upper load, becoming to a "triple a" underground continuous wall with a set of retaining, load and waterproof. In recent years, the use of underground continuous wall in the foundation engineering has become increasingly widespread, more used in coastal soft soil area of the deep foundation of high-rise buildings, basement walls, protective walls and deep foundation protection. The rigidity of the diaphragm wall is large, it not only can block the soil and can be waterproof. There is low noise, no vibration, no squeezing soil.It is applicable to all kinds of soil layers, but also can be used in reverse construction with a lot of advantages:

With a wide range of uses, being suitable for a wide range of application. It can be used for seepage prevention, water interception, bearing, retaining soil, anti slide and other uses.

When construct, there is no vibration, low noise, not disturbing, and the influence on adjacent buildings and underground pipelines is small.

The stratum adaptability is very strong. For many layers that can high-efficiency groove.

With fully mechanized operation, high work efficiency, fast construction speed.

When casting, without support and maintenance, which can save construction costs and materials, and can be constructed in low temperature.

5. Conclusion

Looking back at the beginning of twenty-first Century, China's economy has made brilliant achievements, which provides a good conditions for the development of foundation engineering .The development of foundation engineering has great significance to the construction project, great achievements of construction project also nurture the development of foundation engineering.

The national "Thirteen Five-Year" plans the grand blueprint for national economic and social development of our country. For construction, municipal, water conservancy, rail transit, it proposed higher requirements, under the condition of ensuring the safety to reduce the impact on the surrounding environment, using new materials, new technology and to construct a group of scientists studio in the dominant research, cultivate a group of top-notch young talents in key areas of science.

This is undoubtedly to provide a strong guarantee conditions for the basic engineering disciplines. Looking forward to the future, efforts and opportunities, we should joint efforts to push the foundation engineering discipline to a new level.

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