Study on Influencing Factors of Vertical Bearing Capacity of Bored Cast-in-situ Pile and Promoting Measures

Wenjia Song

Xi'an International University, Xi'an, Shaanxi, 710077, China

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Abstract: In this paper, the factors affecting bored cast-in-place pile vertical bearing capacity are analyzed, including the geometric characteristics of piles, the properties of soil around piles and the distribution of soil layers, and the strength and deformation properties of the bearing layer at the end of piles. According to each influencing factor, the corresponding suggestions for improvement measures are proposed one by one.

1. Introduction

With the development of high-rise buildings toward "high, large, heavy and deep", bored cast-in-place pile is more and more widely used in high-rise building foundation engineering because of its large bearing capacity, small settlement, good stability, variable pile diameter and pile length [1]. However, due to the constraints of construction methods, the process of pile formation is concealed, and there are many factors affecting Vertical bearing capacity of single pile. In addition, bored cast-in place pile has a high cost [2]. By improving the bearing capacity of concrete of the pile body per unit volume, the number of piles arranged can be reduced and the project cost can be reduced [3]. Another exception is that due to the limitation of specific conditions, it is not possible to increase the length of pile, nor is it appropriate to expand the diameter of pile, but must improve the bearing capacity of single pile [4]. Therefore, it is of great significance to study measures to improve the vertical bearing capacity of single piles of bored piles.

2. Bored cast-in-place pile Vertical bearing capacity of single pile

According to the load transfer mechanism of bored cast-in-place pile under compression, the bearing capacity of vertical single pile is closely related to pile body, rock and soil properties at pile tip, pile length, cross-sectional characteristics of pile, pile diameter and pile-forming technology.

2.1 Geometric characteristics of piles

The total side resistance of the pile is proportional to its surface area, so the larger specific surface area (the ratio of surface area to pile volume A/V) can increase the bearing capacity of the pile. The length, diameter and ratio (length to diameter ratio L/D) of the pile are one of the main factors affecting the ratio of the total side resistance to the total end resistance, the degree of pile end resistance and the bearing capacity of the single pile. The bearing capacity of single pile can be obviously different with the same soil layer, different length-diameter ratio, same material amount and different pile length and diameter.

2.2 The properties and soil layer distribution of pile side soil

The strength and deformation properties of pile side soil affect the performance and size of pile side resistance, and thus the bearing capacity of single pile. Some properties of pile side soil, such as collapsibility, dilatancy, liquefiability, under-consolidation, etc., will cause the pile side resistance to decrease under certain conditions, and even negative friction resistance, thus significantly reducing the single pile bearing capacity.

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The distribution of the soil side of the pile not only affects the distribution of the pile side resistance along the pile body, but also affects the bearing capacity of the single pile. If the collapsible soil, the liquefiable soil, and the under-consolidated soil layer are distributed in the lower part of the pile body, the neutral point depth of the negative frictional resistance caused by the settlement of these soil layers is greater than the distribution of these soil layers on the upper part of the pile body. In this case, the pull-down load of the single pile is increased, and the bearing capacity is decreased. The relative position of soft and hard soil, cohesive soil and non-cohesive soil also affects the pile side resistance.

2.3 Strength and deformation properties of pile tip bearing layer

Pile tip bearing layer plays a decisive role in bearing capacity and deformation of single pile. The influence degree of pile tip bearing layer on vertical bearing capacity decreases with the increase of pile length-diameter ratio L/D, increases with the increase of pile-soil modulus ratio Ep/Es, and increases with the increase of pile side and pile side soil modulus ratio Esb/Ess.

2.4 Material strength of pile body

When the bearing strength of the pile tip is high, the strength of the pile body material may limit the vertical bearing capacity of the pile. Because of the appropriate concrete strength grade and reinforcement, it is very important to make full use of the load bearing performance of the pile tip bearing layer to improve the bearing capacity of the single pile.

2.5 Depth effect of pile tip resistance and pile side resistance

The results of indoor model test and prototype test show that when pile tip enters the uniform bearing layer with depth h less than a certain depth, its ultimate end resistance increases linearly with depth; when the depth of pile tip enters the uniform bearing layer, the ultimate end resistance remains basically constant. The critical depth of pile tip resistance increases with the increase of pile diameter.

When there is a soft underlying layer under the pile tip and the distance between the pile tip and the soft underlayer is less than a certain thickness, the end resistance will be reduced by the soft underlayer. When the depth of the pile into the soil exceeds a certain depth, the side resistance no longer increases with increasing depth.

2.6 Time effect of bearing capacity of single pile

The time effect of bearing capacity of pile means that the vertical limit of the pile increases in a certain way with time. The general rule of change is that the initial growth rate is fast, then gradually slow, after a certain period of time tends to a certain limit value. Due to the fact that borehole perfusion produces no soil squeezing effect and does not cause superpore water pressure in the process of pile formation, and the soil disturbance range is small, the time effect of bearing capacity is smaller than that of the pile. In cohesive soils, bored cast-in-place pilebearing capacity of pile changes with time mainly due to the disturbance of pore-wall soil during pore-forming process and the gradual recovery of lost strength with time due to thixotropy of soil. In the case of mud retaining piles, thixotropic hardening also occurs in the mud attached to the hole wall. Therefore, the time effect of bearing capacity is more obvious than that of dry operation. In the latter case, the disturbance range of pore wall soil is small, and its bearing capacity effect can be generally neglected.

2.7 Pile-forming effect of bored cast-in-place pile

The bored cast-in-position pile causes the stress and strain fields in the soil around the pile to change due to the pile-forming process. The effect of the corresponding change in the pile side resistance is called pile side resistance. During the hole formation process, the loose effect of the hole wall soil causes the soil strength to weaken and the pile side resistance to decrease. On the other hand, when pore forming and concrete pouring, the water content of the soil around the pile is increased, the clay at the interface between the pile and the soil is softened, and the adhesion on the

bored cast-in-place pile is lowered. The end effect of the bored cast-in-place pile is the pile effect, which means that disturbance, sediment or virtual soil occurs during the hole formation process and the end resistance is reduced.

2.8 Overpressure and grouting pressure in concrete pouring

When the concrete is poured underwater, the difference between the static pressure of the concrete mixture column in the pipe outlet section and the static pressure of the mud column outside the pipe is called the overpressure. Its value is related to the perfusion radius of the catheter, which is related to the flow index time of concrete mixture in the catheter and the buried depth of the catheter. The main reason is that the long time of pouring concrete, the deep buried pipe and the small overpressure lead to the occurrence of mud inclusion and segregation in shallow concrete, which results in the decrease of bearing capacity. The pressure grouting technology implemented in recent years in China has an important impact on improving bearing capacity of pile.

3. Measures to enhance bored cast-in-place pile Vertical bearing capacity of single pile

3.1 Design measures

3.1.1 Design of special-shaped piles

Among all pile types, the equal-diameter shape, that is, the cylindrical pile bearing capacity is the smallest. Simply increasing the diameter of the pile can increase the bearing capacity of the pile, but the increase is far less than that of the irregular variable diameter pile. Therefore, in the case of insufficient resistance of pile side, in recent years some units have designed and developed various types of shaped piles, such as concave and convex pile or slub pile, multi-bearing force plate concrete bearing pile and so on, improving the bearing capacity of pile.

3.1.2 Design of enlarged bottom pile

In order to increase the bearing capacity of pile by increasing the bearing area of pile tip, the bearing capacity of pile can be increased several times by using expanded bottom pile and increasing the bearing area of pile.

3.1.3 Choosing reasonable bearing layer and thickness of bearing layer

Although the length-to-diameter ratio L/d of the bored cast-in-place pile increases, the effect of the pile tip soil on the bearing capacity is reduced. However, whether it is an end bearing pile or a friction pile, the pile tip is designed on a harder bearing layer. In the present case, it is still important to increase the bearing capacity of the pile.

3.1.4 Design of rock-socketed piles

The bored cast-in-place pile is designed as a rock-socketed pile to make full use of the high bearing capacity and low compressibility of the bedrock and improve the bearing capacity of a single pile.

3.2 Construction measures

According to the above analysis, the Bored cast-in-place pile Vertical bearing capacity of the pile factor, and summed up many domestic and international engineering practice experience, the above measures can be used to effectively improve the bored cast-in-line pile.

(1) pile side and pile bottom pressure grouting technology are adopted.
(2) Construction by borehole grouting method.
(3) Ensure the strength of pile body material.
(4) To ensure the quality of hole cleaning.
(5) Non-circular rotary digging method is used to drill holes.

The non-circular rotary excavation method can not only greatly improve the efficiency of hole-forming and avoid the pollution of mud circulation, but also, more importantly, because the pile side friction of single pile can be improved by the non-mud skin on the hole wall.

(6) Mud type selection and performance control.

On the premise of ensuring that the hole wall does not collapse and the quality of hole formation, the appropriate mud type should be selected, and the mud performance index in drilling should be controlled within the range specified in the specification.

(7) Ensure the rock-socketed depth of pile tip bearing stratum.

(8) To shorten the waiting time of pile holes and ensure the quality of concrete pouring.

3.3 Management measures

As a hidden project, the quality control of bored cast-in place pile is focused on the accuracy of the test and the timeliness of the cooperation between the test and the construction. The dynamic control Table, which can be compiled according to different periods of the pile-forming process, is very effective for the dynamic control of both progress and quality. In addition, strengthen the project supervision work, especially the key aspects of the key links (such as aperture, hole depth, verticality, sediment and dredging and perfusion quality) that affect the bored cast-in-place pile bearing capacity, so as to ensure the quality of the project.

4. Conclusion

Bored cast-in-place pile is widely used in current engineering practice. Vertical bearing capacity of single pile of bored cast-in-place pile is a basic content in pile foundation theory, and it is also a basic problem that needs to be determined first in pile foundation design. Therefore, research into a new method of increasing the bored cast-in-place pile bearing capacity of piles will have significant social and economic benefits.

References

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