Influence Analysis of Large-area PHC Pipe Pile Construction on the Surrounding Environment in Deep Silt Site

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Abstract. There are a large number of deep and thick soft soil foundations along the river and coastal areas. PHC pipe piles have become one of the foundation treatment methods widely used in soft soil foundations. Taking the construction of a pile foundation project in Wenzhou as an example, the thickness of the dredger fill and silt at the site is 27.20–33.60m, and the impact of large-area pile group construction on the surrounding environment is discussed. The results show that: (1) The load imposed on the pile top and the pile sinking depth during the construction of the foundation pile increase according to an exponential function. (2) The direction of horizontal soil squeezing deformation around the field is related to the position of the measuring point. The corner range is small and the middle range is larger, but the direction of maximum displacement is basically along the shortest line between the pile position and the measuring point. (3) The vertical direction of the measuring point varies greatly with the construction time and pile position, and the uplift and settlement appear repeatedly. The monitoring results can provide a reference for the construction of similar projects.

1. Introduction

The beach area belongs to the reclaimed foundation soil. PHC pipe piles are widely used in the treatment of such soft soil foundations. However, the squeezing effect caused by the pipe piles may cause the foundations of adjacent buildings to rise, structural deformation, and damage the surrounding municipal roads and a series of environmental accidents such as underground pipeline and slope instability [1].

In order to reveal the internal mechanism of the soil squeezing disturbance effect, scholars such as Vesic [2], Randolph [3], Carter [4] and other scholars successively used circular hole expansion theory to solve the influence of single pile static pressure on the surrounding soil. Luo Zhanyou [5] and Zhang Yaodong [6] analyzed the soil squeezing effect through the strain path method and the source-sink method. Theory is the basis of analysis, and it is also necessary for engineering monitoring and analysis. Cao Xiujuan [7] and Tian Zhenghong [8] combined with engineering monitoring data, pointed out that measures can be used to adjust the piling sequence to reduce the amount of daily piling or stop piling to control the soil squeezing effect; Wang Yaowu [9] pointed out through monitoring and analysis that the effective radius of influence of pore water pressure is about 15m for static pressure PHC pipe piles in saturated soil; Lu Qun [10] pointed out that the pressed pile has obvious screening effect through monitoring and analysis, and the soil displacement and excess pore
pressure on the facing pile surface are much larger than the back pile surface; Li Guowei [11] analyzed the impact of soil squeezing on the road, and pointed out that the pipe pile construction on the widened foundation site has little impact on the old road foundation, and the old road embankment has a restraining effect on the horizontal displacement in the direction perpendicular to the roadbed; Jia Zhigang [12] pointed out that the maximum influence radius of excess pore water pressure was about 29 times the pile diameter through field monitoring of clay soil foundation; Bie Xiaoyong [13] pointed out according to the clay site engineering monitoring that the impact of dense cluster piles is larger than that of single piles, and 5mm deep soil horizontal displacement is still measured at a distance of 20d from the pile foundation; LiLianghui [14] analyzed the environmental impact of hammered pipe pile construction in deep soft soil areas through monitoring and gave treatment measures; Li Shuanglong [15] analyzed the impact of large-area static pressure pipe piles on the silty clay foundation on the adjacent site soil, and pointed out that the lateral horizontal disturbance deformation of the soil first increased and then gradually stabilized with the increase in the number of pile rows. The displacement development experienced three stages: fast, slow and gradually stable. The displacement of the surface uplift decayed exponentially with the increase of the horizontal distance from the test pile area.

The above researches are based on the engineering monitoring of clay foundations or small-area pile groups, and there is a lack of research on the environmental impact of large-area pile driving and soil squeezing effects on deep silt sites. Taking a pile foundation project in Wenzhou City as the background, the soil displacement at a specific location around the site was monitored during the construction of the PHC pipe pile, and the law of the surface soil displacement around the site and the distance between the pile groups caused by the pile foundation construction on the site was studied. The construction of similar sites has certain reference significance.

2. Project overview

2.1 General Situation of Engineering Geology
A large area of plain fill was backfilled in the site, and it was hydraulically filled into land in 2013. Dredger fill and siltated soft soil are characterized by high water content, high compressibility, low shear strength, high sensitivity, and poor bearing capacity. The thickness of the soft soil layer is 27.20m~33.60m, and the groundwater depth is 1.29m~3.21m.

2.2 Layout of Foundation Piles and Monitoring Points
The foundation adopts pile foundation. The foundation pile adopt PHC-500 (100), and PHC-600 (110). The concrete strength is C80, and the pile end bearing layer is layers of clay. The characteristic value of the vertical bearing capacity of a single pile is 1100kN, the vertical ultimate bearing capacity of a single pile is 2200kN, the characteristic value of the horizontal bearing capacity is 24kN, and the characteristic value of the uplift pile: the characteristic value of the uplift bearing capacity is 200kN. The layout of site buildings and pile foundations is shown in Figure 1. The effective pile length is not less than 47m. The pile diameter is 500 mm (or 600mm), the total number of piles is 7512. The pile spacing is 3.0m×3.0m, 4.8m×3.6m and 4.0m×4.0m and so on.

The Pile foundation construction adopts an improved static and dynamic combination pile driver. Electricity is used in the static pressure stage, and fuel is used to provide power only after entering the bearing layer, thus reducing pollution and reducing piles caused by vibration. The top offset also reduces the construction cost per linear meter. The construction zoning is carried out at the same time, starting on October 3, 2018, and will be basically completed on April 6, 2019. The number of piles
pressed into each device varies from 5 to 13 piles per day, and it is adjusted according to the deformation and deformation speed monitored on site. In order to study the impact of large-scale construction on the surrounding environment of a deep silt site, ground surface deformation measurement points are arranged near the densely packed piles of the site, as shown in Figure 1. Strictly control the piling schedule and daily piling volume during the construction process, implement informationized construction, and use monitoring results to guide the construction to ensure the construction quality of precast piles.

The static pressure $Q$ and the depth $z$ of the pile are exponentially related during the pile sinking process:

$$Q = 14.669 \exp(z/11.191) + 224.432 \quad \text{(for PHC-500(100); R-Square=0.9945)}$$

$$Q = 11.806 \exp(z/11.654) + 343.563 \quad \text{(for PHC-600(110); R-Square=0.9769)}$$

3. Monitoring results and analysis

3.1 Monitoring and Analysis of Horizontal Displacement of Surface Soil

The horizontal deformation vector of the measuring point on the east side is shown in Figure 2. The direction of the horizontal radial displacement of the soil is related to the position of the measuring point. The range of the radial displacement of the measuring point at noon on the site is much larger than that of the corner measuring point. The direction of the measuring point CJ3 is between 0 and 360°, and the direction of the maximum displacement of the measuring point is basically in the connecting direction of the pile position and the measuring point. The maximum radial displacement of the soil is 92.20mm, at the measuring point CJ1-1. The horizontal deformation vector of the measuring point on the south side is shown in Figure 3. The direction of CJ7-2 is between 0 and 360°, and the direction of the maximum displacement of the measuring point changes around 210°. The maximum displacement of the radial squeezing soil is 140 mm. At the measuring point CJ8, the displacement direction range is between 175 and 200°.

The horizontal deformation vector of the measuring point on the west side is shown in Figure 4. The radial displacement direction of the measuring point gradually increases from the bottom, and the maximum displacement direction is between 240 and 270°. The maximum radial displacement of the soil is the value is 127.5mm, at the measuring point CJ10-2.
3.2 Monitoring and analysis of vertical displacement of surface soil

The vertical displacement of the measuring point is shown in Figure 5. The positive displacement is taken as the surface soil uplift, and the negative displacement change is the surface soil settlement. It can be seen from Figure 5 that the vertical displacement of the measuring points around the site...
fluctuates greatly with time. The CJ3 measuring point on the east side is dominated by settlement, and the maximum settlement is 60mm. Uplifts appear on individual days, and the maximum uplift value is about 80mm. Mainly uplift, the maximum uplift is 90mm. The south and west sides are dominated by subsidence. The maximum settlement value on the south side is about 120mm on the 70th day, the maximum uplift is on the 62nd day, and the maximum is 90mm. The maximum settlement on the west side is 100mm on the 45th day, and the maximum uplift value is 70mm on the 62nd day.

Figure 5. The vertical deformation of the pavement monitoring point changes with the construction time

4. Conclusion
(1) The load imposed on the pile top and the pile sinking depth during the construction of the foundation pile increase exponentially.
(2) The direction of horizontal soil squeezing deformation around the field is related to the position of the measuring point. The corner range is small and the middle range is larger, but the direction of maximum displacement is basically along the shortest line between the pile position and the measuring point.
(3) The vertical displacement around the factory area varies greatly with the construction time and construction pile position, and uplifts and settlements occur repeatedly.

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