

The Research of Raft Foundation Anti-floating Piles' Performance and its Impact on the Raft Foundation

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Abstract. By using the finite element software ANSYS and ABAQUS, we established the calculation model of raft foundation anti-floating pile foundation, and studied the mechanical properties of the raft foundation and the influence of raft foundation on the foundation. By comparing the stress and displacement of the anti-floating pile under different pile distance, the influence trend of the different anti-floating pile layout scheme on the mechanical property of the floating slab foundation anti-floating pile is explained, Then the optimal arrangement scheme of anti-floating pile was acquired. Under the action of vertical load, the anti-floating pile effectively reduces the average vertical displacement of the raft, and the raft foundation improves the bearing efficiency of the pile as well as the economic efficiency.

1 Introduction

In recent years, the underground structure has become more and more deep, and the traditional anti-buoyancy measures have been unable to meet the demands of practical engineering. For example, the method of drainage precipitation and construction on both the sides. causes waste and pollution of fresh water resources, also causes uneven settlement of surrounding buildings. At home and abroad, the theoretical research on anti-floating pile is far behind its application in practical engineering^[1]. About the study of anti-floating pile's bearing capacity, scholars merely stay on the basic of experience and similarity, who pay main focus on the basic design principles of anti-floating pile. In 1987, Madhav^[2] proposed a theoretical analysis method for calculating the efficiency coefficient of the anti-pulling group pile. Madhav used the boundary element method to analyze the effect of the interaction of two piles on the ultimate friction resistance of the pile side, and then applies the superposition principle to the pile group. In 2004, Maharaj^[3] used nonlinear finite-element method to study the load-bearing capacity of the single pile and pile. The results showed that if the concrete volume, the tensile strength of the shear bearing capacity of the variable section pile is significantly increased is the same. The above analysis is to construct single pile and bearing capacity of pile body parameter and the performance group of research, on the basic of analysis an research about the influence of the anti-floating pile's stress and the raft foundational stress, this article puts forward a new design concept, which makes the raft foundational and anti-floating pile combine in wu garden community. The finite-element software ANSYS and ABAQUS were used to establish a calculation model of raft foundation anti-floating pile group. Furtherly the anti-floating pile

bearing capacity factors, the anti-uplift mechanical properties and the impact on the raft foundation stress were studied, establish a raft foundation anti-floating calculation model of pile group of anti-floating pile bearing capacity factors, pile raft foundation anti-uplift mechanical properties and impact on the raft foundation stress were studied.

2 Project Overview

Since this article is based on FengCheng wu garden community in Laiwu city village renovation project, including stratigraphic structure and mechanical properties, the basic situation of proposed construction have been conformed. We changed the pile number by changing the pile spacing ultimately affected the transfer between pile soil mechanics, eventually to analyze raft foundation, the mechanical properties of anti-floating pile group under the effect of buoyancy.

The proposed site is located in the south of fengcheng street in laiwu city and west of the garden south road. Proposed, the construction project consists of two 26 stories, one 24 floors, one 20 floors, commercial buildings and underground garage. The design period of the building is 50 years, and the classification of seismic fortification is standard fortification. We select No.2 building structure, 28.3 meters long, 12.7 meters wide, 20/2D layers height, shear wall structure, raft foundation, unit load 280KPa, foundation buried depth 9.0 meters, base elevation 181.7 meters, leveling elevation 190.7 meters. The site conditions are shown in table 1.

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Table 1. Site formation structure and rock and soil physical and mechanical properties

| The species of soil | Layer thickness/m | Uniaxial compressive strength/MPa | | | | | | |
|---------------------------------|-------------------|-----------------------------------|---------------|-------------|---------------|--------------------|--------------------------|----------------|
| | | Maximum value | Minimum value | Data number | Average value | Standard deviation | Coefficient of variation | Standard value |
| Miscellaneous fill | 0.90-6.30 | - | - | - | - | - | - | - |
| Silty clay | 1.3-6.60 | 1.7 | 4.7 | 45 | 2.7 | 0.7 | 0.25 | 2.5 |
| Fully weathered fine sandstone | 0.60-2.40 | 1.9 | 2.6 | 22 | 2.2 | 0.2 | 0.11 | 2.3 |
| Strong weathered fine sandstone | 3.90-7.90 | 2.15 | 2.93 | 9 | 2.52 | 0.25 | 0.10 | 2.36 |
| Medium weathered fine sandstone | 0.50-17.50 | 4.20 | 8.40 | 7 | 6.01 | 1.31 | 0.22 | 5.04 |

3 The Establishment Of Abaqus Calculation Model.

The soil body adopts mohr-coulomb model, and the calculation parameters are shown in table 2. Elastic model is adopted in the pile body, and the calculation parameters are shown in table 3. The other parameters remain unchanged when a single parameter changes.

According to the calculation process of ABAQUS, we firstly established a three-dimensional geometric model of pile-soil and then divided it into grids. In this paper, the pile surface of the pile-soil contact surface is designated as the main surface, and the soil as from surface. After consulting the literature, the friction coefficient of the contact surface is 0.55.

Set 4 groups of working conditions, the pile spacing is 4D, 5D, 6D, 7D respectively, D is the pile diameter. The working condition of each group has two kinds of load: one is water buoyancy added to calculating model, and the other is upper

structure load and water buoyancy added to calculating model.

3.1 Influence of pile spacing on displacement of anti-floating pile.

Figure 1 is the load-displacement diagram of the anti-floating pile under the action of buoyancy, and the displacement cloud map of different pile spacing of the anti-floating pile is taken, as shown in Figure 2. As the distance between the pile decreases, the lateral friction resistance of the pile soil is affected, so the ultimate anti-floating bearing capacity of the anti-floating single pile decreases. The smaller the pile spacing, the greater the impact. In practical engineering design, the influence of pile spacing on soil friction resistance of pile side must be considered. When the pile number is certain, and when the buoyancy load value is certain.

The floating displacement of pile group increases with the increase of pile spacing. As the load increases gradually, the curvature of the curve becomes large.

Table 2. Mechanical model parameters of soil.

| Pile length L/m | Length of cross section of pile /m | Modulus of elasticity E/GPa | Density $\rho/kg/m^3$ | Poisson ratio μ |
|-----------------|------------------------------------|-----------------------------|-----------------------|---------------------|
| 16 | 0.4 | 30 | 2500 | 0.15 |

Table 3. Mechanical model parameters of pile body.

| Density $\rho/kg/m^3$ | Modulus of elasticity E /MPa | Poisson ratio μ | Cohesive force C/kPa | Internal friction angle $\Phi/^\circ$ | Expansion angle $\Psi/^\circ$ |
|-----------------------|------------------------------|---------------------|----------------------|---------------------------------------|-------------------------------|
| 18 | 15 | 0.3 | 10 | 20 | 8 |

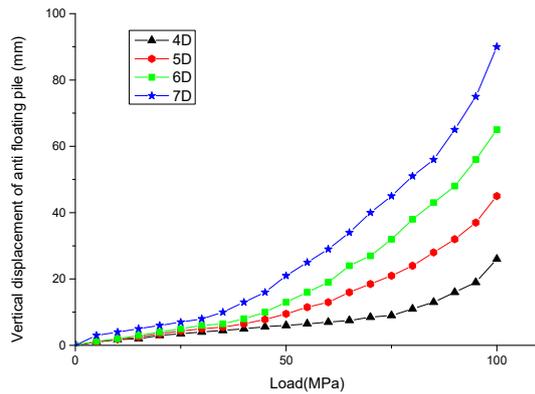
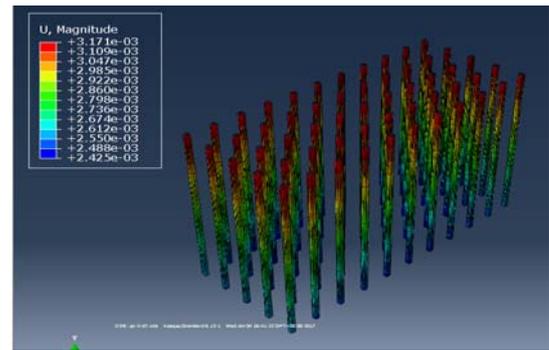
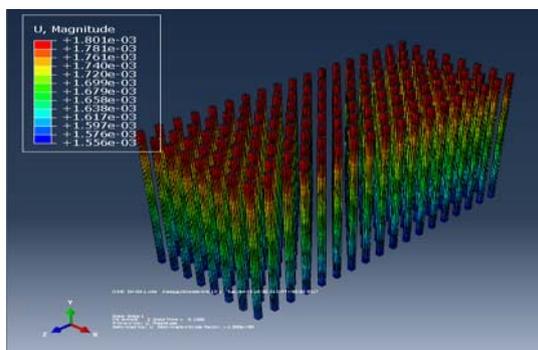


Figure 1. load displacement curves of anti-floating piles with different pile spacing conditions

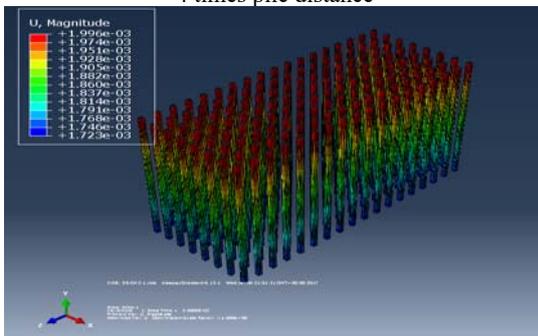


7 times pile distance

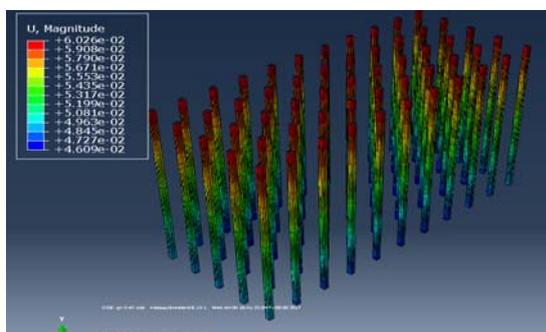
Figure 2. displacement cloud chart of anti-floating pile group under different pile spacing conditions



4 times pile distance



5 times pile distance



6 times pile distance

3.2 The influence of pile spacing on the internal force of the anti-floating pile group.

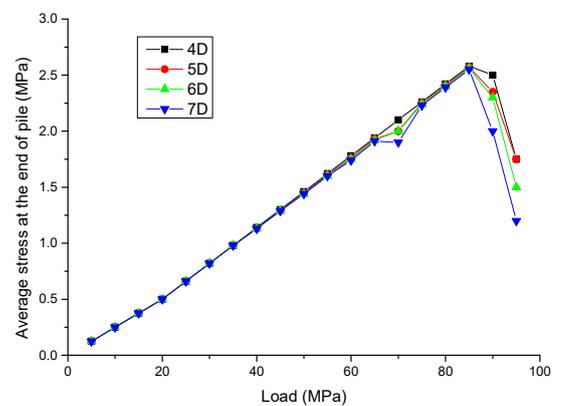


Figure 3. curves of average stress on top of anti-floating piles under different pile spacing

As shown in figure 3, anti-floating pile top under the conditions of different pile spacing average stress graph, the tensile stress in the pile end is also increasing, with the increase of the buoyancy, when the buoyancy acting on the anti-floating pile is greater than the anti-floating pile side friction, the relative slip between anti-floating pile and soil occurs.

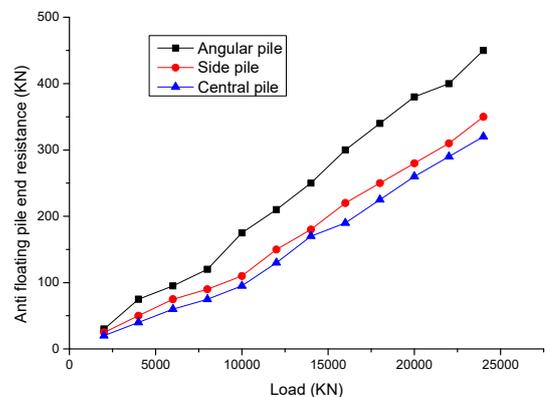


Figure 4. top down tension diagram of anti-floating pile group (6 times pile spacing)

Figure 4 is 6 times the pile spacing, and the anti-floating pile is pulled at the bottom of the pile of the Angle pile, side pile and central pile under the action of buoyancy. The load on the central pile is the minimum, the side pile is bigger, angle pile is the biggest load. Along with the load increases, the load on the center pile increases constantly, and the load on the corner pile decreases gradually. Therefore, the load on central pile, corner pile and side pile is always in dynamic change.

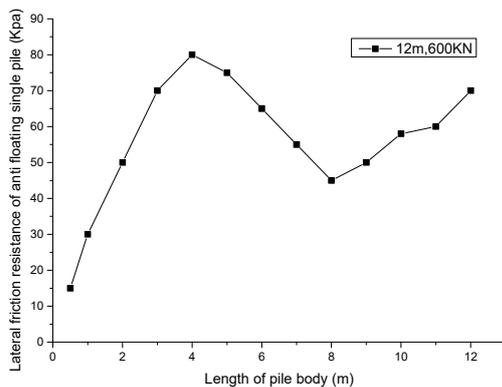


Figure 5. side frictional resistance diagram of anti-floating single pile under buoyancy

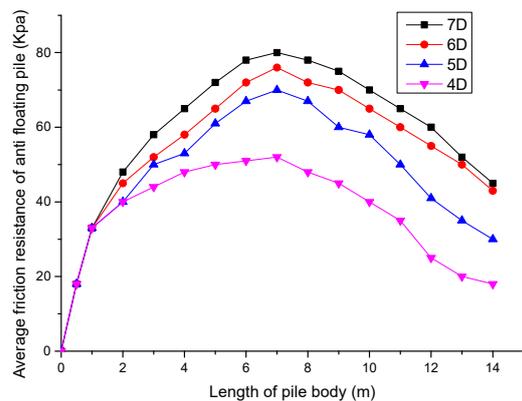


Figure 6. side frictional resistance diagram of anti-floating group piles under buoyancy

Figure 5 is pile length is 16 m, diameter of 800 mm anti-floating pile, under the effect of 600 kn pull up along the pile side friction of pile distribution diagram, figure 6 is up under the action of tension, pile spacing, respectively 4D, 5D, 6D and 7D anti-floating group average friction resistance of pile side. The lateral friction of anti-floating pile with large spacing of piles is larger than that of pile spacing. The lateral compression of the soil between the piles can cause the lateral friction of the pile in the middle of the pile to become larger.

4 Analysis of the influence of raft Foundation on the stress in the later stage.

4.1 Finite element model

In order to investigate the influence of anti-floating pile on raft foundation, the loading is divided into two steps. First, when the anti-floating pile does not exist, the superstructure load is only borne by the raft foundation; second, according to Figure 7, the anti-floating pile [4], after the normal use of the building, the superstructure load is jointly borne by the raft and anti-floating pile. As shown in Figure 8, the loading calculation diagram shows that the superstructure load is F_3 - foundation reaction force and F_4 - anti-floating pile reaction force.

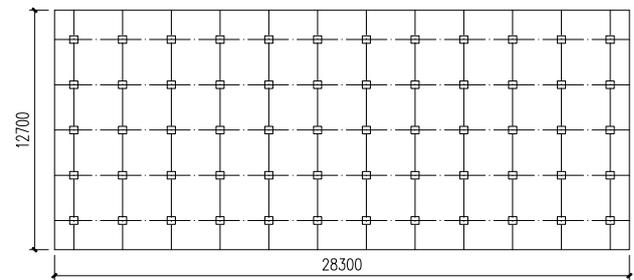


Figure 7. layout drawing of anti-floating pile

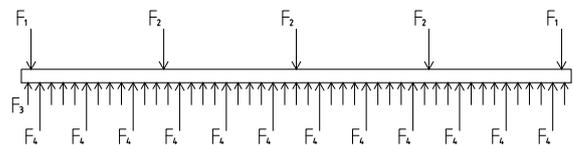


Figure 8. simple diagram of vertical loading of raft

4.2 Influence of anti-floating pile on internal force of raft foundation

As shown in Figure 9, when the anti-floating pile exists, there is stress concentration in the contact position between the raft foundation and the anti-floating pile, but when the anti-floating pile does not exist, the internal force distribution of the raft is more uniform. In the contact position between raft and anti-floating pile, it is better to design a cap to reduce the impact shear effect of concentrated stress on the raft, and to improve the overall punching shear ability. Finally, in order to ensure the safety of raft, the reinforcement of bearing and mid-section of anti-floating pile should be much larger than that of raft, and more reinforcement should be added in these positions.

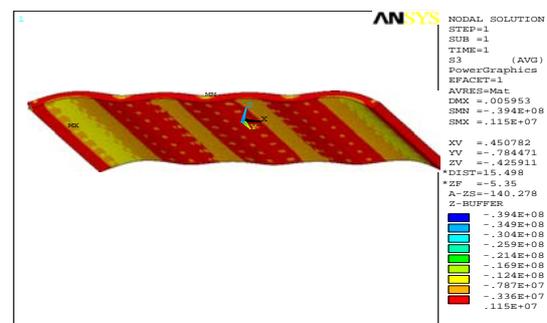


Figure 9. stress concentration chart of raft plate in the presence of anti-floating pile

4.3 Effect of anti-floating pile on deformation of raft foundation

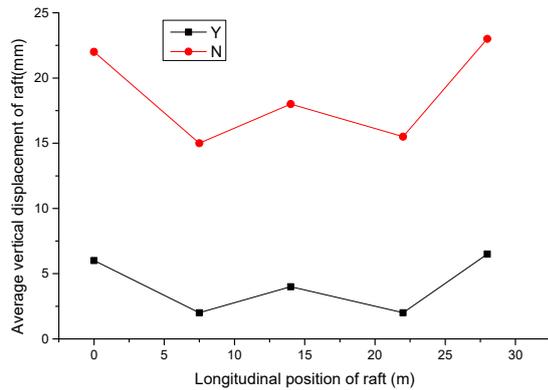


Figure 10. chart of average vertical displacement of raft

Under the action of vertical load, the maximum vertical displacement of raft is about 21mm and the average vertical displacement is about 17.06mm when the anti floating pile does not exist. The maximum vertical displacement of raft plate is about 6mm after the anti floating pile is added, and the average vertical displacement is about 3.1mm. anti floating pile, and the average vertical displacement value of raft is reduced.

5 Conclusion

The effect of pile spacing on the mechanical properties of anti-floating pile group of raft foundation is studied. Under vertical load, the bearing efficiency of single pile is obviously different with different pile spacing and pile number. In the aspect of vertical displacement, with the increase of pile spacing, the vertical displacement of raft foundation anti-floating pile is also increasing. In the actual engineering design, it is necessary to select appropriate pile spacing and pile number, which cannot only reduce the total displacement and deformation of the foundation, but also improve the bearing efficiency of pile group foundation.

Under the action of buoyancy, the existence of anti-floating pile reduces the average vertical displacement of raft foundation.

Stress concentration occurs in the contact position of raft foundation and anti-floating pile. In order to ensure the safety of pile-raft contact, the anti-floating pile design of raft foundation should be checked and calculated to ensure the safety of pile-raft contact.

Reference

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