THE INFLUENCE OF PILE CAP ON BEARING CAPACITY OF PILE GROUP

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Abstract*: This research shows the influence of pile cap on bearing capacity of pile foundation, especially pile groups of shaft resistance. Using PLAXIS-3D FOUNDATION sofware to simulate a actual application with 4 piles in groups and assumption for 7 stiffness modulus of soil under pile cap. The output calculation expresses that in both the cap and the pile carrying the load. The cap is necessary to spread the vertical and horizontal loads and any overturning moments to all the piles in group and transfer load to soil underneath.*

Keywords: Influence, pile cap, bearing capacity, transfer, shaft resistance.

1. INTRODUCTION

Piles are vertical or slightly inclined, relatively slender structural foundation members. They transmit loads from the superstructure to competent soil layers. Length, method of instalation, and way of transferring the load to the soil can vary greatly. In some cases, the piles serve only to improve the bearing capacity, density, or stiffness of the surrounding soil without directly carrying the load of the structure.

The connection between the superstructure and the pile is call pile cap. The upper of the pile (the end connection to the pile cap) is called the pile head, and the bottom end is called the pile toe. What lies between the pile head and the pile toe is called the pile shaft. Piles can be used singly or in groups. Mostly, piles are placed in groups. The behavior of a single pile is different from that of an individual pile in a group. A pile group can consist of a cluster of piles, where the group effect is governing in all directions of load and movement, or consist of a row of piles (a pile bent) where the pile behavior is governed by the group effect in one direction of load and movement, while in the orthogonal direction the piles are independent of the group and behave as single piles.

The determination for load of pile depend on assumtion that loading transfer only on piles, no thing to soil between piles. This calculation lead to error because loading not only acting on the pile but also transfer in the soil around pile via pile cap. If the soil beneath pile cap bear part of loading then the bearing capacity of file foundation will have significant increase. There were several field tests by P.G. Tsijikov and Vu Cong Ngu reveal this comment. Two pile foundations with 9 piles of earch and the distance between pile is 3 times of pile diameter was done by P.G. Tsijikov. The one has pile cap on the ground surface and the other has pile cap above ground surface about 1 meter. The result test shows that the foundation, which has pile cap on the ground surface, can bear 3950 tones. But the foundation, which has pile cap above ground surface, only reach 2650 tones, much more decrease loading. Several field tests were done by Vu Cong Ngu at Haiphong in soft soil that has the same results. This means that, piles cap has apparent effect to bearing capacity of piles in group.

2. RESEARCH METHODS

Using PLAXIS 3D FOUNDATION sofware to simulate for piles in group of 4 with the same loading and soil strata properties. The one of simulation for pile cap on the ground surface and the other simulation for pile cap above ground surface. In case of pile cap on the ground surface, considering with many modulus of soil under neath pile cap or can say another way that change stiffness of thin soil layer directly under pile cap. In order to keep no change of shaft resistance, the soil layer directly under pile cap is used about 20 cm in simulation.

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3. SCOPE OF RESEARCH

Research on small dimension of piles group about 4 piles in group with only one level load. The pile are all vertical. Load is applied at the center of the pile group. The pile group is symmetrical and the pile cap is very rigid. The single pile and mat pile foundation are excepted in this research.

4. SIMULATION OF PILE FOUNDATION

4.1 Structure of pile foundation and loading condition

A heavy column foundation, which is to support a vertical load of 3700 kN, the horizoltal load is 260 kN will be placed at a site where the soils consist of an upper 2.6 m thick layer of high clay (CH), fine sand followed by 2.5 m thick and high mudy clay 13.1 m thick lower. Under high mudy clay lies a very thick layer of low clay (CL).

The groundwater table is located at the 1.6 m below ground surface and the pore water pressure in the soil is hydrostatically distributed

The pile foundation must be pile-supported and it has been decided to use 4 driven, 0.25 x 0.25 metter square, precast, concrete piles. The pile will have to go well in to the low clay layer with the embedment length of the pile is 21.7 m

The pile cap has three dimensions (1.6 x 1.6 x 0.8) with 4 piles in group, bottom of pile cap lower than ground surface 1.6 metter.

Table 1: Geotechnical Parameters

Parameter	*Units*	*CH-Clay*	*Fine Sand*	*Muddy Clay*	*CL-Clay*
Thickness	m	2.6	2.5	13.1	20
Unit Weight	kN/m^3	17.6	17.5	16.6	18.3
Modulus	kN/m^2	**500-3500**	5000	4000	18000
Poisson Coef	-	0.25	0.25	0.25	0.25
Model Analysis	-	Morh-Coulomb	Morh-Coulomb	Morh-Coulomb	Morh-Coulomb
Cohesion	kN/m^2	10.5	12	7.5	18
Friction Angle	Degree	5.5	15	7.5	23

The effect of pile cap to bearing capacity of pile foundation is simulated in two cases. The one, wich has pile cap on the ground surface and the other has pile cap above the ground surface. In the first case, there are 7 values of modulus, were assumed in range from 500 kN/m^2 to 3500 kN/m^2 in order to show that the stiffness of soil layer under neath pile cap effect to the settlement of pile foundation.

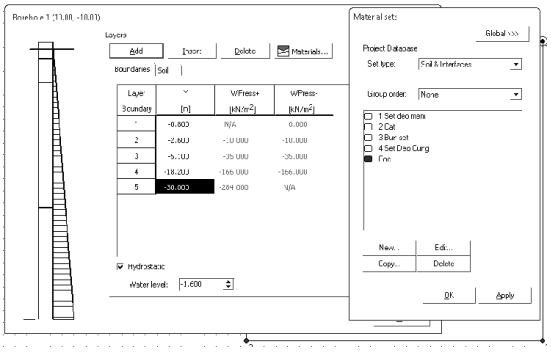
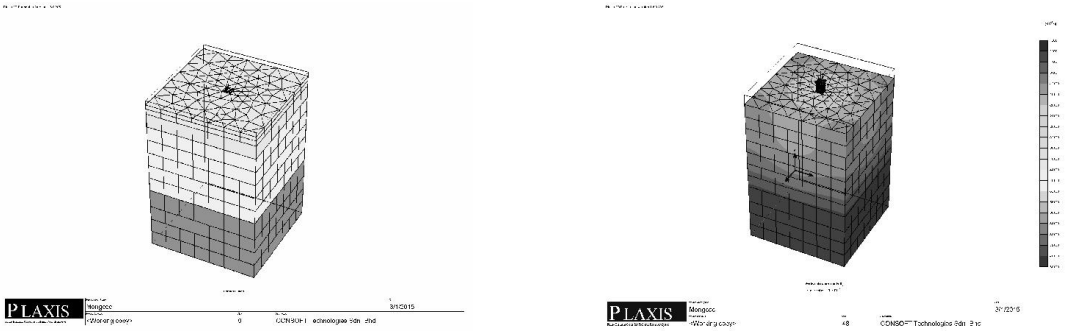


Figure 1: Simulation of geotechnical conditions.

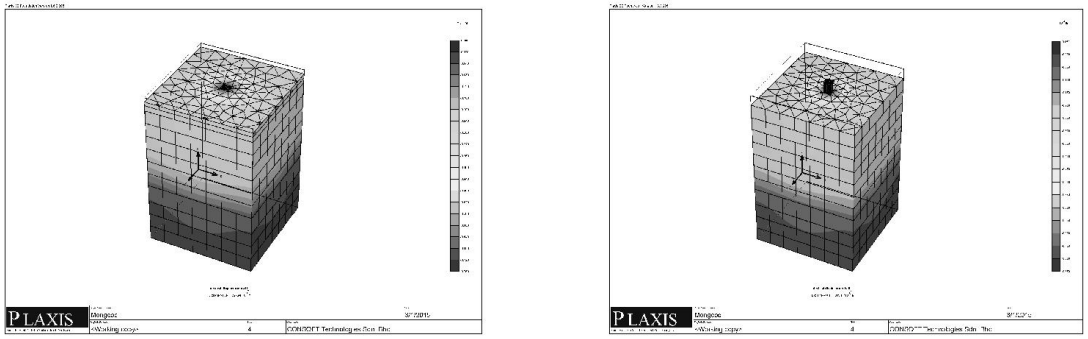
4.2 The Input simulation of Pile Foundation



Case 1: Pile cap on the ground surface Case 2: Pile cap above the ground surface

Figure 2: Simulation of pile foundation

4.3 Discussion of output



Case 1: Pile cap on the ground surface Case 2: Pile cap above the ground surface

Figure 3: Output calculation of pile foundation

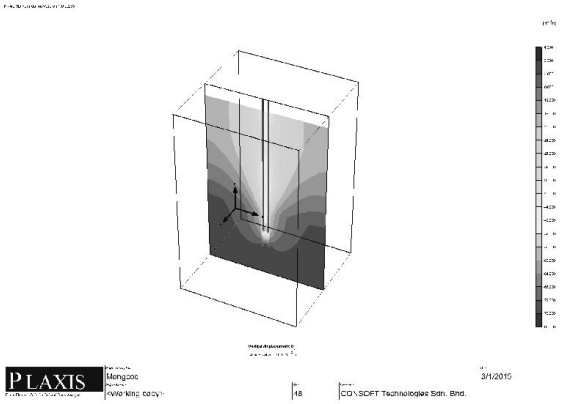


Figure 4: Output calculation of vertical displacement

Sumaries all circumstances are simulated by PLAXIS-3D-FOUNDATION, the pile foundation with pile cap and without pile cap have many differences, especially in settlement of file foundation. The stiffness of soil layer contact pile cap has much more effect to settlement of pile group.

Table 2: Sumaries all circumstances are caculated

No	Assumtion of modulus value of first soil layer under pile cap (kN/m^2)	The values of settlement with pile cap contac the soil (mm)	The values of settlement with pile cap above the soil surface (mm)	The different values of settlement between two type of pile foundations	Percentage of difference
1	500	73	76	3	4%
2	1000	70	76	6	8.2%
3	1500	68	76	8	11.7%
4	2000	64	76	12	18.7%
5	2500	60	76	16	26%
6	3000	60	76	16	26%
7	3500	60	76	16	26%

In seven values of modulus were assummed in table 2, the values of settlement of foundation with pile cap and without pile cap are closed. When the values of modulus rearch at 2500 kN/m^2 and bigger, the values of settlement with pile cap on the surface is very smaller than

values of settlement with the pile cap above the soil surface. The different values of settlement between two type of pile foundation is 16 mm, about 26% of difference.

Pile cap has effect to bearing capacity of foundation, especially when the stiffness of soil under pile cap higher than 2500 kN/m^2. This means that, load on the pile cap transfer a part of load to soil under pile cap but not absolutely transfer to piles in group.

5. ANALYSIS OF APPLICATION

In this part, the structure is introduced that a pier bridge of fishing habour at Soc Trang province. Base on geotechnical properties and terrain conditions at site structure, this project has 15 piers are pile foundations with pile cap on the soil surface and 16 piers are pile foundations with pile cap above the soil surface.

Figure 3 shows two typical piers , MT 15 is low pile cap and MT16 is high pile cap, but the embedment lengh of piles in two group are the same. Because of effect pile cap position, there is a difference settlement between MT15 and MT16.

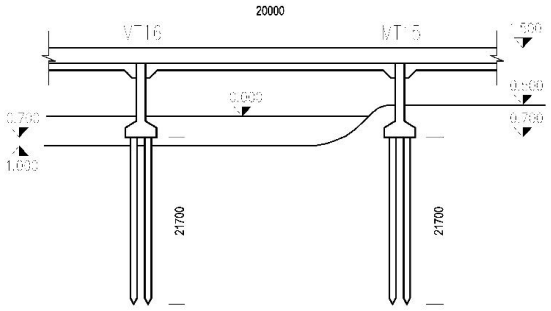


Figure 3: Two typical piers of bridge for fishing habour

Table 3: Geotechnical Parameters of Soc Trang project

Parameter	*Units*	*CH-Clay*	*Fine Sand*	*Muddy Clay*	*CL-Clay*
Thickness	m	2.6	2.5	13.1	20
Unit Weight	kN/m^3	17.6	17.5	16.6	18.3
Modulus	kN/m^2	**960**	5000	4000	18000
Poisson Coef	-	0.25	0.25	0.25	0.25
Model Analysis	-	Morh-Coulomb	Morh-Coulomb	Morh-Coulomb	Morh-Coulomb
Cohesion	kN/m^2	10.5	12	7.5	18
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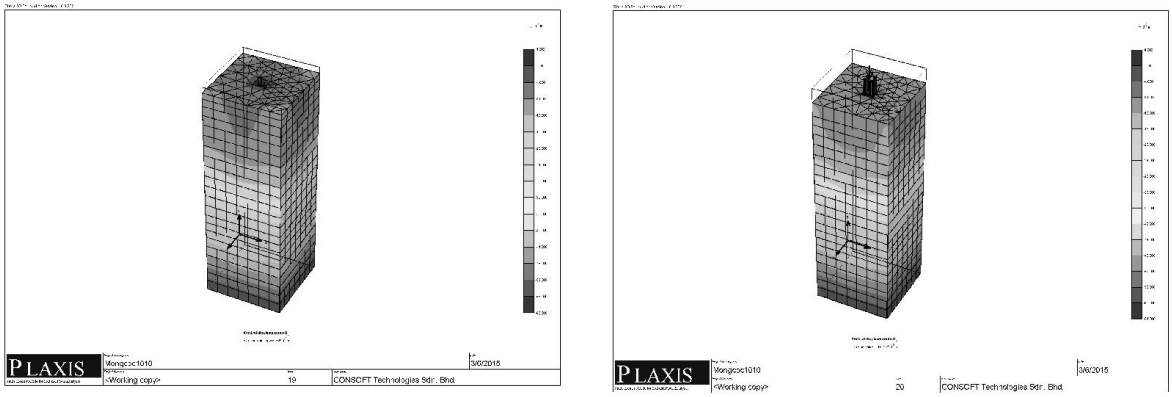
Using PLAXIS-3D FOUNDATION to check for settlement of MT15 (low pile cap), 4 piles in group, section area 0.25 x 0.25 m, embedment length 20 m, the value of settlement is 0.0508 m.

To check for MT16 (pile cap above ground), if the value of settlement still keep 0.0508 m then the required embedment length of pile will be 22 m, longer than 2 m in compared to pile in MT 15.



a) MT15-Pile cap contact soil

b) MT16-Pile cap above ground

Figure 4: Check for settlement of pile group

6. CONCLUSIONS

The assumption that each pile in a group carries an equal load may be nearly correct when the pile cap is in contact with the ground.

Base on output analysises and the results of application reveals that influence of pile cap in direct contact with soil. This means that in both the cap and the pile carrying the load, a cap is necessary to spread the vertical and horizontal loads and any overturning moments to all the piles in group and transfer load to soil underneath pile cap.

The design considers the influences of pile cap on bearing capacity of group pile, especially with pile foundation that is placed on softsoil. In order to avoid the different in settlement between pile cap contact ground and pile cap above ground, the pile groups should be calculated independence to chose a reasonable embedment length of pile.

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Tóm tắt

ẢNH HƯỞNG CỦA ĐÀI CỌC ĐẾN SỨC CHỊU TẢI CỦA NHÓM CỌC

Bài báo nêu kết quả nghiên cứu ảnh hưởng của đài cọc đến sức chịu tải của móng cọc đặc biệt là móng cọc sức kháng ma sát (cọc treo). Nghiên cứu sử dụng phần mềm PLAXIS-3D FOUNDATION để mô phỏng ứng dụng móng cọc thực tế có 4 cọc với giả thiết 7 trị số độ cứng mô đun biến dạng của đất ngay dưới đáy đài. Kết quả tính toán mô phỏng chỉ rõ ảnh hưởng đài cọc đến sức chịu tải của cọc. Đài cọc đảm nhiệm phân phối tải trọng đứng và ngang, mô ment tới tất cả các cọc đồng thời còn truyền tải trọng vào lớp đất dưới đáy đài.

Từ khóa: Ảnh hưởng, đài cọc, sức chịu tải, truyền tải, sức kháng ma sát.

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