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Effect of the Pile & Cap Connection Type in Liquefiable Sand

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ABSTRACT: The type of pile-to-cap connection in pile foundations is a subject that is always discussed in geotechnical engineering. In this paper, the comparison between two hinged and fixed pile to cap connection types has been accomplished and the earthquake response of the pile group has been measured with shear and axial forces, vertical and horizontal displacement and bending moment through the length of the pile. Therefore a dynamic 3D analysis under earthquake load was used in finite element software ANSYS and the results were compared. Finally, comparisons show that hinged connection minimizes vertical displacement and fixed connection minimizes shear and axial forces and bending moment.

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1. INTRODUCTION

Piles function in liquefiable soils is much more complicated than that of un-liquefiable soils. Because in these soils besides that pile is under different dynamic loads of soil and structure, also the soil resistance and rigidity will decrease during time by soil nonlinear behavior and increasing pore water pressure [1]. In 1964 by Alaska and Niigata earthquakes, many damages occur with leaning many structures which had a significant role in attracting geotechnical experts[2]. To study about liquefaction phenomenon one impressive element in pile group function is the connection of pile to the cap which implements by two fixed and hinged methods [3]. In the past studies about connection type have mentioned increasing share of piles load, axial load and bending moment especially in inclined pile with hinged connection [4]. In this paper, to find the optimum connection type of pile to cap in pile group under dynamic load, used modeling in finite element software by the dynamic behavior of pile group in liquefiable soil and focusing on connection type of pile to cap.

2. SOIL AND PILE SYSTEM MODELING

The constructed 3D model including two-layer whose top layer is liquefiable and the bottom layer is compacted sand. The constructed piles are in 2*3 pile group and main model with 0.5 m diameter with 10 m length which the last 1 m is in compacted soil. The following tables show the properties of soils and pile used in modeling.

Fig. 1 shows the main model used in the analysis.

3. LOADING

To consider the upper structure effect, distributed compressive load applied to the upper surface of the pile cap is 700 KN, and also the ground acceleration is 9.81 $\frac{m}{s^2}$. To apply the dynamic load, earthquake load assigned to lower nodes was used. For selecting earthquake, displacement record of Turkey Kocaeli earthquake applied as critical earthquake by comparison between different earthquakes frequency and system natural frequency, considering resonance phenomenon.

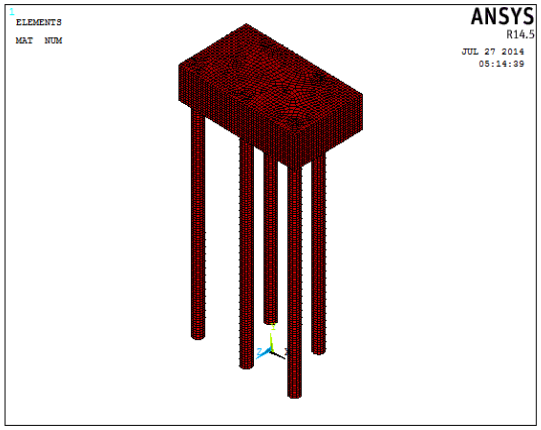

Fig. 1. Main modeling.

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Table 1. Soil properties.

Soil type	υ	ρ $(\frac{kg}{m^3})$	C (Kpa)	φ	V_S $(\frac{m}{s})$	E (Mpa)
Liquefiable sand	0.3	1885	1.5	33	100	**17.5**
Compacted sand	0.2	2015	2	40	220	**81**

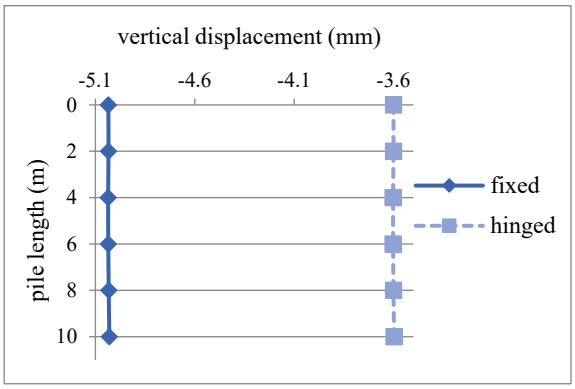

Fig. 2. Effect of Pile & cap connection type on vertical displacement

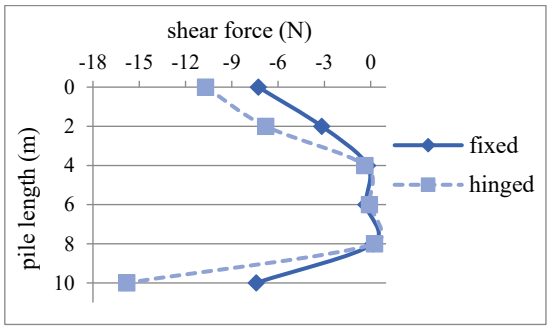

Fig. 3. Effect of Pile & cap connection type on the shear force.

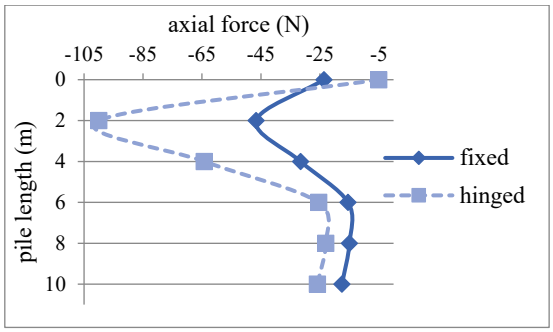

Fig. 4. Effect of Pile & cap connection type on the axial force.

Table 2. Pile properties.

E (Mpa)	υ	ρ (kg/m^3)
20000	0.2	**2400**

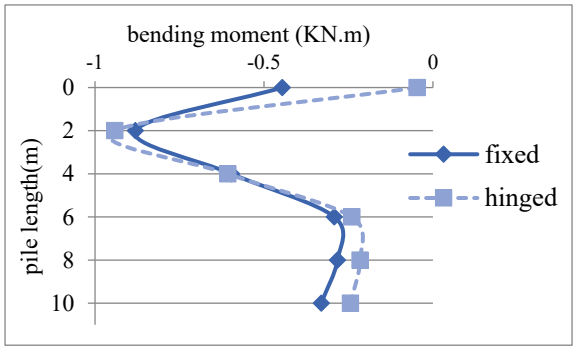

Fig. 5. Effect of Pile & cap connection type on bending moment.

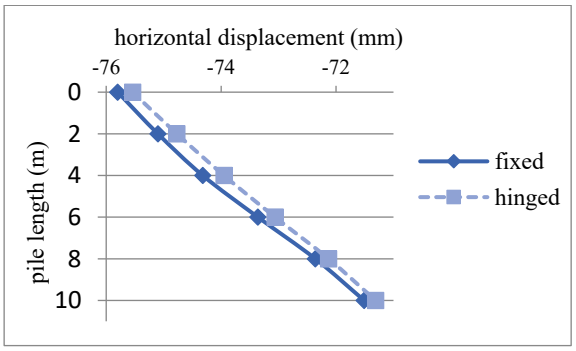

Fig. 6. Effect of Pile & cap connection type on horizontal displacement.

4. RESULTS AND CONCLUSIONS

Comparisons between fixed and hinged connection analysis shown in Figs. 2-6.

The result of pile group analysis shows that:

- Type of pile connection to cap, has a slight 0.3 percent effect on the horizontal displacement that present connection to cap type doesn't have a considerable effect to pile horizontal displacement.

- The pile with a hinged connection to the cap has optimum settlement because in this case, the maximum settlement is 39 percent lower than the fixed connection.

- Fixed connection piles have an optimum condition in axial force by decreasing 114 percent than the hinged connection.

- Fixed connection has optimum 113 percent shear and 7 percent bending moment than the hinged connection, which shows significant effect of connection type to shear force than axial force.

- For both connection types, the maximum horizontal displacement induces at the pile to cap connection, maximum axial force and bending moment induce at 2-meter depth, and maximum shear force induced in 10-meter depth while the vertical displacement is almost the same along the pile length.

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