第Ⅲ部門 Investigation on effect of bearing layer thickness on pile tip behavior using centrifuge model tests

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Introduction

End bearing pile foundations are used in superstructures that require a high resistance. However, in some locations, the thickness of the dense soil layer supporting the pile may be below the standards due to the natural geological features in the area. Thus, it is important to determine the effect of the layer thickness on the bearing characteristics of piles. Numerical studies have evaluated the effect of the layer thickness on the bearing capacity[1]. However, there exist few experimental investigations.

The objective of the current study is to conduct centrifuge model tests to investigate the effect of the bearing layer thickness on the end bearing capacity and the horizontal earth pressure in the soil surrounding the pile tip.

Methodology

The experiments were conducted using the geotechnical centrifuge at the Disaster Prevention Research Institute (DPRI) at Kyoto University. A scale factor of $N = 50$ (50g) was used. The model pile was made of stainless steel with a diameter D of 20 mm and height of 210 mm. The bearing layer was made of Silica Sand No. 5 ($D_r = 90\%$), which was underlain by loose Toyoura Sand ($D_r = 20\%$).

Figure 1 shows the experimental set-up. A total of eight tests were performed. Five (5) of which corresponded to five cases with varying bearing layer thickness. The last three tests corresponded to three of the cases with four 3-MPa earth pressure gauges (EPG) positioned in the soil surrounding the pile tip to measure horizontal earth pressure values: (1) 8D-EPG, (2) 3D-EPG, (3) 1D-EPG. **Figure 2** shows the position of the EPGs. The loading rate used was 0.6 mm/min.

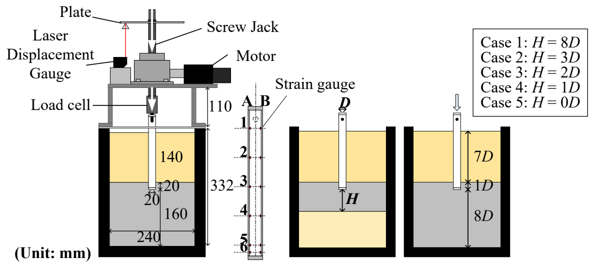

Figure 1. Experimental set-up and cases

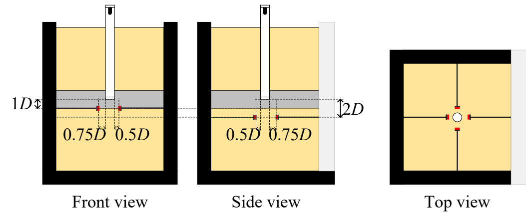

Figure 2. Position of horizontal earth pressure gauges

Table 1. Soil Properties

	Toyoura Sand	Silica Sand No. 5
Specific Gravity G_s	2.640	2.640
Mean Particle Diameter (mm)	0.200	0.438
Min. Void Ratio e_{min}	0.585	0.699
Max. Void Ratio e_{max}	0.975	0.961
Cohesion c (kPa)	0	0
Friction Angle (deg)	33.4	33.0

Results

End Bearing Capacity

Figure 3 shows the end bearing capacity values for each case, which were obtained by subtracting the friction in the upper layer from the axial load above the ground surface at a displacement of

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0.10D. Here, friction was calculated using the average difference in the axial load values in the upper Toyoura layer. It is found that the capacity increases with the layer thickness up to H/D of 3, consistent with the previous result[1]. Moreover, using the projected area method[2] and the bearing layer capacity of Case 5 as the value of q_l, the appropriate spread angle θ was found to be 23°, which is consistent with the previous result[2] despite the difference in materials used.

Horizontal Earth Pressure in Surrounding Soil

Figure 4 shows the change in horizontal earth pressure due to loading. The relative values of the three cases are compared. There is an increasing similarity in the curves from both gauges located 1D below the pile tip as the bearing layer thickness increases. It is hypothesized that a thicker layer would result to a wider local failure zone, resulting in these gauges to be more within this zone.

Moreover, the larger pressure values obtained for a thicker layer are hypothesized to be correlated with lower displacement values due to the higher confining pressure. These hypotheses were confirmed with a previous analysis on the displacement field of a similar case[3]. Thus, assuming the bulb-shaped failure zone surrounding the compressed wedge under the pile tip, the zone corresponding to high displacement values increases in width as the bearing layer thickness decreases. The lower pressure values for a thin layer further suggest the rapid downward expansion of the failure zone, penetrating the lower layer at a lower displacement. Furthermore, the higher capacity values are correlated with the higher confining pressure for a thicker layer.

Conclusions

The end bearing capacity increases with thickness up to an H/D of 3. A spread angle of 23° is suggested for the projected area method for a thin layer. Moreover, the horizontal earth pressure beneath the pile tip increases with the layer thickness. This suggests that the zone corresponding to high displacement decreases in width as the bearing layer thickness increases due to the higher confining pressure, which is further correlated with the higher bearing capacity values.

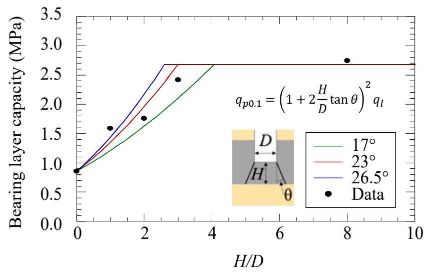

Figure 3. End bearing capacity with curves obtained using the projected area method

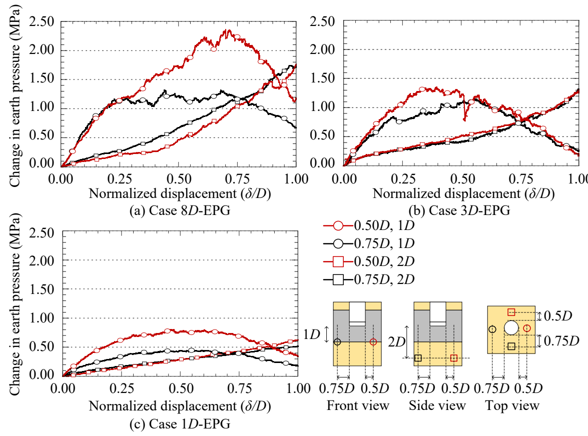

Figure 4. Change in horizontal earth pressure due to loading for each case

Acknowledgements

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References

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