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Set-up Influence on Axial Capacity Increase of Driven Piles

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ABSTRACT

The soil set up, a phenomenon of time-dependent bearing capacity increase of driven piles, has gained significant attention by researchers. The history of soil set-up can be traced back to 100 years ago where it was first mentioned by Wendel[6] (1900). The first well-documented case of pile set-up in non-cohesive soils, not attributable to pore water pressure changes, was presented by Tavenas and Audy[5] (1972) and Chow et al.[1] (1997) who performed tension tests on open-ended-324 mm diameter steel pipe piles at sand site in France. The result shows that the long-term set-up was normally in the range of 50 to 150 percent of the initial pile capacity. Time-dependent pile capacity increase depends on many factors such as soil grain characteristics, in-situ stress level, pile geometry, chemical processes and pile installation. As the pile is driven, the installation induces major displacement or shear strains in the soil adjacent to the pile shaft. Such displacement causes the pore water pressure in the soil surrounding the pile to increase. In cohesionless soil, the excess pore water pressure dissipates quickly. The excess pore water pressures induced by pile driving seldom exceed 20% of the effective overburden stress.

In this paper, an investigation was made on set up phenomenon for driven piles. For this investigation, the results of PDA tests performed on piles initially after driving and also at re-strike driving are considered and compared with results of static loading on the same piles from viewpoint of set up. The main goal of this survey is to investigate the effect of soil set-up on the pile axial capacity following the installation of the pile using the pile driving technique.

Key words: Pile axial capacity, set up, pile driving.

1. Introduction

Pile driven into saturated clays increases the excess pore water pressures. This excess pore water pressure decreases the pile bearing capacity. Of course this process is temporary and the capacity reterns when these pressures dissipate, a process known as Set-Up.
It is obvious the bearing capacity that is based on data obtained during driving is less than actual capacity.
The engineers use restrike blow counts in these soile after a few days to consider the soil set-up effects [2].
It is believed that set-up some time occurs in non-cohesive soils due to [4]:

- Chemical effects which may cause the sand particles to bond to the pile surface
- Soil ageing effects resulting in increase in shear strength and stiffness with time.
- Change of radial effective stress due to creep effects or relaxation on the established circumferential arching around the pile shaft during installation.

Pile installation in clay is different from that in sand. Soil in the immediate vicinity of the pile is significantly remolded by the driving process and excess pore water pressures generate. Subsequently, this causes re-consolidation resulting increase of pile capacity. In the subsequent section, this phenomenon is investigated using data from field tests.

2. Case Studies

2.1 case I

As an example, a case study is considered here using data from field tests on a driven concrete pile. In this case, the length of the tested pile was 24 m. The croos section of the pile was square with 0.4 m width.
The local soil generally consisted of 5 layers as follow [3]:
Layer1: from ground level to a depth of -13 m, the soil was predominantly soft clay.
Layer 2: from depth -13 to depth -24 m, non-cohesive soil, predominantly silty-sand is present.
Layer 3: from depth -24 m to -29 m, the soil profile was similar to the first layer.
Layer 4: from depth -29 m to -38 m, the soil profile was similar to the second layer.
Layer 5: from depth -35 m to -40 m, the soil profile was similar to first layer.
The pile was installed into the ground such that the first half was embedded in the cohesion soil and the other half was embedded in non-cohesive soil.

2.2 Results

Following the pile installation, PDA tests were performed on the pile and analyses were carried out by CAPWAP. The following results presented in Table 1 were obtained.

Test name	Pile capacity in initial strike (kN)	Time after initial strike	pile capacity in re strike (kN)	Percentage Increase in Capacity
P1	1706	2 days	2134	25
P2	1200	6 days	1261	5
P3	1302	6 days	1680	29
P4	2050	28 days	3099	51

Table 1. Pile bearing capacity at initial strike and re-strike

As seen, after 2 days, there is %25 increase in the pile1 capacity. After 6 days, this increase accounts for %5 in pile 2 and %29 in pile 3. After 28 days, the pile capacity increase is %51 in pile 4. Fig. 1 summarizes the results.

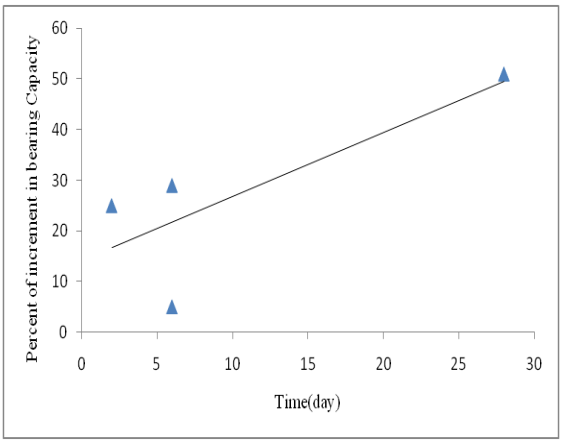
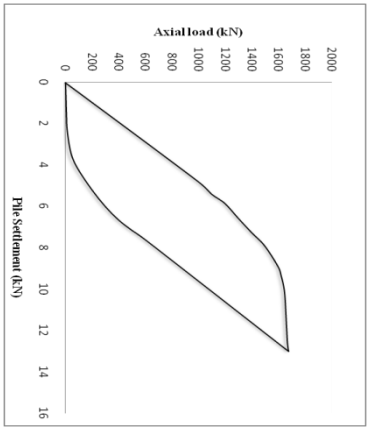


Fig 1: Pile capacity increase with time

After performing dynamic test on the above mentioned pile, a static test was conducted on pile 3 and displacement was recorded using 4 gages with 0.01mm accuracy. The pile was loaded by 120 or 150 tons step by step incrementally. The pile settlement value was continued at 8 min for each loading step until the displacement became less than 0.25 mm per hour. The pile was re-loaded by 220 ton. The total load carried by the pile was 250 ton and the corresponding settlement was 13 mm. The load-displacement diagram from static test is shown in Fig. 2. The load displacement variation was modeled using CAPWAP software. The results are shown in Fig. 3.

Figure 3 shows that the bearing capacity after 6 dayes is about 1680 kN and figure 2 shows that the bearing capacity is about 2500 kN, this increment in bearing capacity is about %49. According to the figure 1, after 23 days the increment in bearing capacity should be about %43. Although the number of case study in this report is not enough, the obteined results is acceptable.



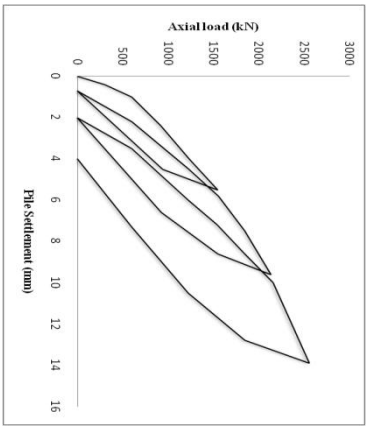


Fig 3: Results from CAPWAP analysis

Fig 2: Results from static load test

3. Conclusion

The general conclusions are:

- According to dynamic tests (PDA), the measured bearing capacity at the beginning and end of re-strike condition shows that the pile bearing capacity increases with time due to set-up.
- The results of static tests show that total ultimate bearing capacity increases with elapsed time and this is attributed to the thixotropy effects in clay.
- According to the results, the bearing capacity can increase even more than %51 because in the report only one pile is tested after 28 days, maybe after some days later the bearing capacity increses.
- It is predict that the bearing capacity increment process continues until the whole of pore water pressure dissipate completely.

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