GENERATION OF EXCESS PORE PRESSURES FROM DTH DRILLED PILES

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KEYWORDS

Piles, Slope stability, DTH drilling, Pore pressures, Clays

ABSTRACT

Piles are frequently installed near slopes in urban environments where the factor of safety for slope stability collapse is low. The installation process can result in excess pore pressure generation and soil displacement which can reduce the stability of the slope and potentially trigger a slope collapse, or horisontal displacements in the soil mass, but there are large differences between the pore pressure generation from various piling methods. Drilled steel piles with down-the-hole (DTH) hammers are an efficient method to penetrate the soil strata and drill the piles into the bedrock. This installation method is considered much safer compared to displacement piles because of the less pronounced soil displacement. Several hammer technologies are available: most are powered by air or by water, in which the hammering and rotating motion is transferred to the drill bit. In the current study, a field test of air- and watered DTH hammers is elaborated, and the differences in the soil response measured and compared previous experience.

1. INTRODUCTION

Piles are frequently the preferred method for foundations in soft soils and transferring the structural loads from the ground surface to more compact soil layer. In construction practice, piling is frequently executed close to existing slopes or nearby natural slopes. The soil mass displacement and generation of excess

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pore pressures in the ground can thereby increase risk of slope collapse in nearby slopes, resulting in a significant hazard during construction.

Several studies of excess pore pressures and soil displacement resulting from pile driving have been presented. The increase in the effective stress state around a bridge abutment was elaborated in Bjerrum and Johannessen (1961). Several methods to reduce the risk of excess pore pressures have been developed, among them prefabricated drains mounted on the piles, (Holtz and Boman, 1974). The risk of landslides resulting from local disturbance in the soil was initially developed by Bernander (2011), discussing several large landslides where piling was assumed to be the triggering agent for the slope collapse.

Alternative methods such as drilled piles have been developed to reduce the risk of excessive ground displacement and excess pre pressures. Drilled steel piles with down-the-hole (DTH) hammers are an efficient method to penetrate the soil strata and drill the piles into the bedrock, which are suitable for soil conditions in which the bedrock can provide bearing capacity of the pile base, (Larisch, 2012). Considering the risk of excess pore pressure, drilled piles have been proven to be a much safer piling method compared to displacement piles because of the less pronounced soil displacement. Several hammer technologies are available: most are driven by air or by water, in which the hammering and rotating motion is transferred to the drill bit. The air-driven technology requires less equipment but can transfer a significant air pressure into the soil during drilling, which can increase the excess pore pressures in the soil and also result in soil displacement. Water-driven hammers cause less pressure generation in the soil due to much lower compressibility of the water, which results in a much lower excess pressure released into the soil during the hammer cycle in the DTH hammer.

A comparison between the DTH hammer methods was demonstrated by Degago and Thakur (2018), when an air-driven hammer was changed to a water driven hammer after the clay fractured during drilling. A study of the mechanism during drilling in sand and a study of different methods was developed by Lande et al. (2021, 2024), in which it was demonstrated that the water-driven method in most cases resulted in less soil disturbance and settlement. However, this study focused mostly on drilled anchors, which are different from piles because of the larger inclination from the vertical and the smaller diameter of the anchor drill bit. In the current study, and series of field tests on drilled steel piles with air driven and water driven DTH hammers in clay are discussed (Ahlund and Ögren, 2016), and the development of the accumulated pore pressure development elaborated.

2. METHODOLOGY

A series of field tests of drilled piles were carried out during a large infrastructure development project south of Stockholm in the municipality of Haninge. The soil profile consisted of 8-9 m of soft marine clay located on top of 2-4 m moraine till on top of Precambrian bedrock. In the pile design, the piles were drilled into the bedrock and the pile bearing capacity was verified by dynamic pile load tests.

A comparative study between the different methods was executed with the field test setup cluster shown in Figure 1. Two symmetrical test setup clusters were installed with 17 m distance between the pore pressures gauges, with sensor 1 located in by the air-driven (AD) cluster and sensor 2 in the water driven (WD) cluster. For each drilling method, two 140 mm diameter steel piles were drilled with 2 m c/c distance, according to Figure 1. Figure 2 shows the drilling of a steel pile with an air driven DTH hammer. Measurements were carried out with a pore-pressure gauge located at 5 m depth, as well as with settlement gauges and settlement screw. Only the pore pressure measurements are discussed in the current study.

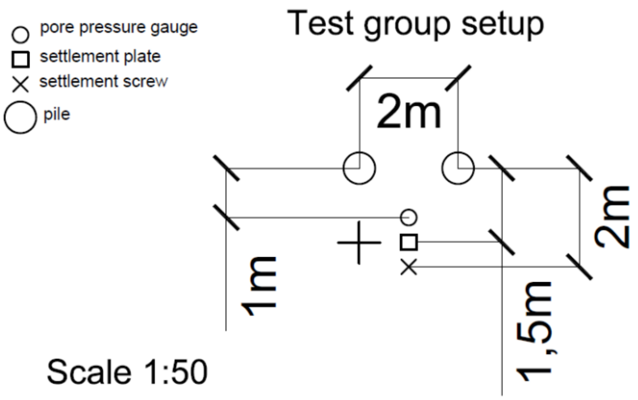

Figure 1. The test set-up for each piling method, consisting of the piles and the measurements devices.

Figure 2. Drilling of a steel pile with an air driven DTH hammer.

3. RESULTS

The piles drilled with the air driven DTH hammer in the AD-cluster was tested first, followed by the piles drilled with the water driven DTH hammer in the WD-cluster. Figures 3 and 4 show the measurements of the total pore pressure and the time when the piles were drilled. Piles 1 and 2 are the drilled by the air-driven DTH method and Piles 3 and 4 by the water-driven method.

Figures 3 and 4 show the recorded total pore pressure and the time gap when the piles were drilled in the AD- and WD-cluster respectively. The excess pore pressures recorded in the AD and the WD-cluster by the air-driven DTH hammer and the water driven DTH hammer are approximately 14 kPa and 3 kPa. Hence the excess pore pressure level from the air-driven DTH hammer around 3-5 times from the water-driven DTH hammer.

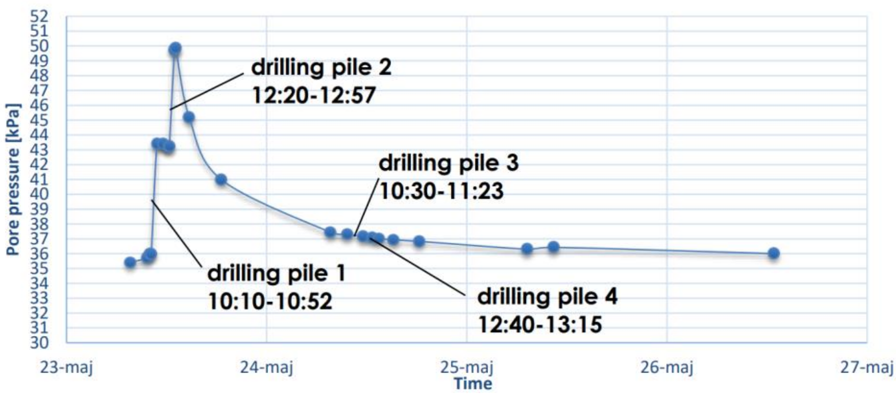

Figure 3. The total pore pressures recorded at the pore pressure gauge 1 located in the AD-cluster.

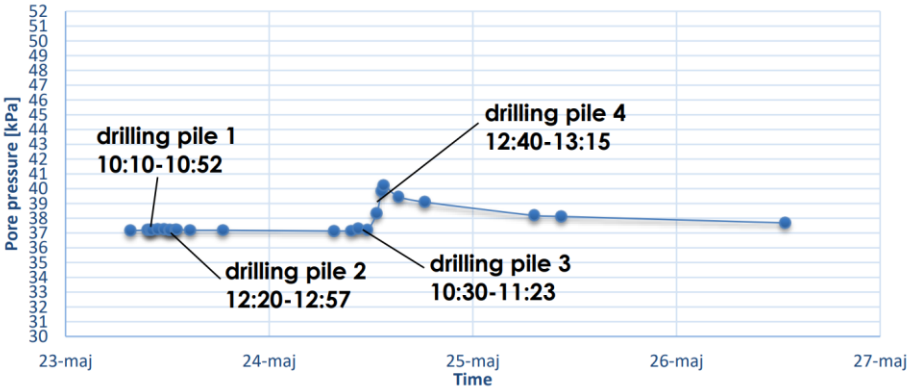

Figure 4. The total pore pressures recorded at the pore pressure gauge 2 located in the WD-cluster.

4. CONCLUSIONS

A field test has been carried out in typical soil conditions in Eastern Sweden to compare the generation of excess pre pressures from piles drilled with air and water driven DTH hammers. The results show that the difference in excess pore pressures between the air- and water driven DTH method are at a ratio of around 4-5, which corresponds to the ratios demonstrated by Lande et al. Hence, the water driven DTH methods should be preferred when there is a risk of land-slides close to the area of piling.

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