Effects of Preloading on PVD Improved Ground with Electro-Osmotic Consolidation

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Introduction

This research dealt with ground improvement by using Prefabricated Vertical Drains (PVDs) for soft Bangkok clay, in order to evaluate the effects of PVD with electro-osmotic consolidation based on the results of one-dimensional consolidation tests. According to the low permeability of clay, the consolidation process takes a long time to achieve. To accelerate this process, vertical drains are installed together with preloading to shorten the drainage path and to gain a rapid increase in strength to improve the stability of structures on weak clay foundations. Consequently, the higher horizontal permeability of clay is also taken advantage. Through the application of electric current using electro-conductive drains as electrodes, consolidation can be further induced must be faster by applying the principles electro-osmosis (EO).

Methodology

The soft Bangkok clay was used as the undisturbed and remolded specimen in this research. It was taken from 3 to 4 m depth in Second Bangkok International Airport (SBIA) which is very soft and dark gray in color. The soil properties are tabulated in Table 1. For reconstituted sample, the remolded sample was reconstituted under 5 kPa pressure until it reached 90% degree of consolidation. The applied vertical pressure increased to 7.5 and 10 kPa during the electro-osmotic consolidation tests for both reconstituted and undisturbed samples. The 60 V/m of voltage gradient was used. The tests were conducted on undisturbed and reconstituted samples using carbon and copper electrodes to study its effects in accelerating the consolidation process. Polarity reversals were carried out every 24 hours. The summary of the tests is given in Table 2.

Table 1:Index properties of soil sample

Properties	Values
W_n, (%)	93.8
W_L, (%)	99.6
W_P, (%)	36.7
PI, (%)	62.9
LI	0.91
G_S	2.65
τ (kPa)	17.7

Results and Discussion

From the consolidation settlement curves as shown in Figure 1, the shape of the settlement-time curves was similar for both radial drainage under vertical load (Test A, B, E and F) and for radial drainage induced by voltage gradient (Test C, D, G, H, I and J) in both undisturbed and reconstituted samples. For the same initial conditions, faster rate of settlement and more magnitude of settlement were achieved using electro-conductive drains than using vertical drains only. For electro-osmosis, the time to achieve 90% consolidation periods range from 1.6 to 1.9 and 1.4 to 2.8 times faster than using drain only for both undisturbed and reconstituted soil samples, respectively. The settlements generated by using electro-conductive drains were in order of 1.2 to 1.4 and 1.4 to 2.6 times higher than that of using drains only. The settlement on undisturbed sample and reconstituted sample can be observed that the settlement generated by electro-osmosis was shown to be dependent of the preconsolidation pressure of soil. Therefore, electro-osmotic consolidation will be less effective in over consolidation clays.

Table 2:Namely type of the tests

Test	Sample	Load (kPa)	Electrode Type
A	Undisturbed	7.5	-
B	Undisturbed	10	-
C	Undisturbed	7.5	Carbon
D	Undisturbed	10	Carbon
E	Reconstituted	7.5	-
F	Reconstituted	10	-
G	Reconstituted	7.5	Copper
H	Reconstituted	10	Carbon
I	Reconstituted	7.5	Copper
J	Reconstituted	10	Carbon

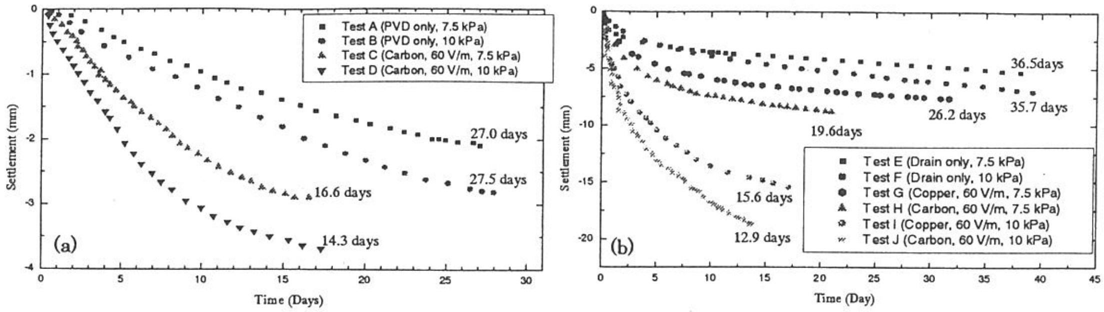

Figure 1 Settlement-Time curve (a) Undisturbed samples and (b) Reconstitutes samples

In the case as shown in Figure 2, greater surcharge load should have been required when using drain only to develop the same settlement, which was achieved by electro-osmotic consolidation. The initial applied stresses of 7.5 and 10 kPa were uniform for 2 main types of tests. From the achieved settlement of each test, the vertical stress required to achieve such settlement magnitude was calculated as shown in Figure 2 for undisturbed and reconstituted sample. Using carbon electrodes, a higher increase in required stress was readily noticeable and a faster rate to achieve such settlement was also verified in Figure 2. Carbon electrode achieved more settlement and faster rate of consolidation since carbon was an inert material to electrolysis reactions, it prevented introduction of additional chemical species that would have complicated the electro-chemistry of the process. The carbon fibers have an open micro porous structure which provides sorption sites. Sorption is one of the potential functions required for electro-conductive drain. The only deficiency of the carbon fiber electrodes is that it would decompose with time and it is easily breakable and torn. The copper electrode was subjected to the oxidation reaction, which has a highly corrosive effect on the electrode. The copper electrode turned into a greenish color, indicating dryness and corrosion. Corrosion affected the performance of copper electrodes, which reduced the efficiency of electro-osmotic treatment.

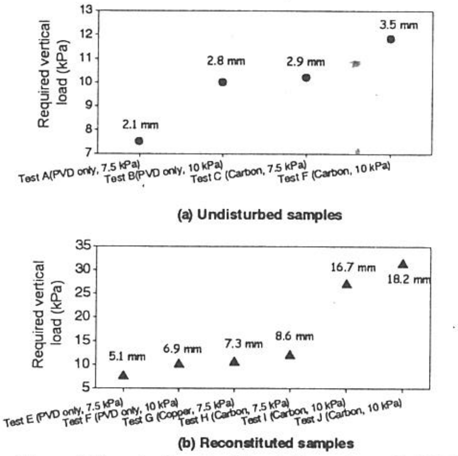

Figure 2 Required vertical loads for using only PVD

Conclusions and Recommendation

1. Electro-osmotic (EO) consolidation can affect the settlement time curve by increasing the rate of the consdidation faster than that using PVD only for both undisturbed and reconstituted samples. As well as, gained more magnitudes of settlement higher than using PVDs only.
2. To get the same value of settlement as using PVD only, it can safe the amount of surcharge load in the case of applying EO consolidation.
3. Carbon electrodes achieved more settlement and faster rate of consolidation than copper electrodes according to highly corrosion in copper rods reducing the advantage of EO.

References

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