Experimental study of bearing capacity pile foundation on peat soil by properties improvement using electrokinetic method and clamshell

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Abstract. Problem always arise when building infrastructure is located on peat soil, such as on a settlement bridge. To know this, an experimental test was conducted. From experimental testing, the PT00 model had the biggest drop at 87.16 mm, for the PT-25V model was 65.30 mm and the PT-KK-25V model amounted to 67.23 mm. For the model of PT00 experienced a faster settlement and small load is 37 kg, model PT-25V can withstand the load up to 49 kg, while for the model PT-KKK-25V, the pile foundation can afford the load up to 204 kg. The peat soil with pile foundation undergoes the fastest decrease of 52.25 mm on the PT-KKK-25V model. For PT00 and PT-25V models subjected to a smaller decrease process of 38.8 mm and 28.78 mm. The results of this analysis can be concluded that for the test pile foundation pressure. The aplication of improvement is more effective on the model PT-KKK-25V, namely pile foundation model is mixed 8% optimum contain of clamshell and electrokinetic with a voltage of 25V. However, for the pile foundation tensile testing, the application of modelling is more effective on the PT-25V type. Because electrokinetic can enlarge the tensile force of the pile foundation.

1. Introduction

Peat soil can be found mostly in Semarang, on of the source is located at Rawa Pening. Peat soil is constructed from dead plant remains which the mildewed and un-mildewed. Peat soil has a very high water content. So that issue emerge when an infrastructure is built on peat soil, example is failure on bridge foundation. It is occured cause to subgrade have the low bearing capacity. To reduce the failure of pile foundation on peat soil, so that improvement on peat soil. Soil improvement can be formed by stabilization addictive substances or reinforcement of pile foundation. Besides only stabilization and reinforcement, can also conducted with electrokinetic process.

2. Literature review

The following is related to this experiment, as follows :

Bisanal M and Badiger R, explained that the unconfined compressive strength and the California bearing ratio of the black cotton soil increases by stabilizing the soil with bitumen emulsion and sea shell powder [1]. Tjandra and Wulandari P S, explained that the results showed that after 24-hour

electrokinetic processes were carried out, the bearing capacity of the pile foundation increased 14 times and the closer to the pile, the shear strength was not trained and increased [2]. K S Wong, Member, ASCE and C I Teh, explained that results of the analysis have confirmed that the proposed approach is capable of predicting with reasonable accuracy the downdrag on single piles [3]. N Ashraf and N Ahmed, explained that the ultimate pull-out capacity of a batter pile constructed in loose sand decreases with the increasing of the batter angle of pile [4]. A Afshin and B K H Bujang, explained that the results of the study showed that the resistivity of the peat decreased as the water content or the temperature increased [5].

3. Methodology

The equipment used for research are as follows:

- LVDT
- Frame Load
- Direct Shear Test
- Chopper
- Cable and pinch
- Power supply
- Multimeter
- Acrylic
- Pull-out testing
- Static Load testing

Figure 1. Research equipment.

Research equipment used to research by know shear strength value, electrokinetic methode and experimental of pile foundation. **Figure 1** are equipment experimental research.

The Material used on research of peat soil, clamshell and pile foundation. The material take from:

- Peat soil taken from Rawa Pening, Semarang – Central Java on **Figure 2**.
- Clamshell located on Sugara Island, Banjarmasin – South Kalimantan, seen on **Figure 4 and 5**.
- Pile foundation made in Material Laboratory Politeknik Negeri Bandung can be seen on **Figure 3**.

Figure 2. Peat soil.

Figure 3. Pile foundation.

The **Figure 2** above shows shape of peat soil in Rawa Pening, Semarang. The peat soil looked black and high water content. Then peat soil contained in box experimental. Sample research is pile foundation can be seen on **Figure 3**.

Figure 4. Clamshell.

Figure 5. Clamshell powder.

For stabilization of peat soil, used material clamshell in Sugara Island, Banjarmasin can be seen on **Figure 4**. The clamshell has been smooth and like be powder seen on **Figure 5**.

Two different material characteristics are conducted SEM test. This test is done to know the unity between peat soil and clamshell. The results of the SEM indicated that there are still cavity in the peat soil that is not filled by clamshell. Because peat soil has an different structure. There are flat, long and irregular shape. While, clamshell shaped are round and like coral can be seen in **Figure 6**.

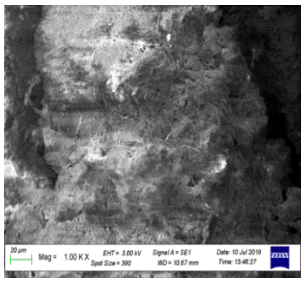

Figure 6. SEM of peat soil mixed clamshell.

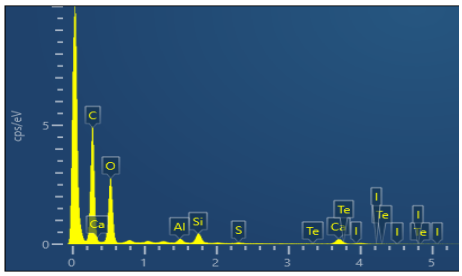

Figure 7. Graph chemical content of peat soil mixed.

The peat soil have chemical content as carbon, oxygen, calsium, alumunium, and silicate. The value of chemical content can be seen on **Figure 7** and **Table 1**.

Table 1. Chemical content of peat soil.

Element	Weight %	Weight % Sigma	Atomic %
Si	6.91	0.14	4.72
O	71.97	0.65	86.28
Ca	12.00	0.25	5.74
S	0.93	0.09	0.55
Al	2.62	0.10	1.86
I	3.23	0.50	0.49
Te	2.34	0.61	0.35
Total	100.00		100.00

Direct shear test using standar ASTM D3080-89. ASTM D3080-89 is standard test method for direct shear test of soils under consolidation drained conditions. The advantages test is to known about shear strength with incremental loading. The shear strength test can use direct shear with sample can be seen on **Figure 8.** Electrokinetic of soil using standard ASTM G187-12a. It's standard test method for measurement of soil resistivity using the two-electrode soil box method. Loading test for pile foundation based on standard ASTM D 1143-81.It's standard test method for piles under static axial compressive load [6].

Figure 8. Direct shear test.

Figure 9. Static loading test.

Pile foundation testing with loading test. Loading test are static loading test (**Figure 9**) and pull-out testing (**Figure 10**). Static loading test use proving ring 10 kN. While pull-out testing using proving ring 28 kN.

Figure 10. Pull-out testing.

Pile foundation for pull-out testing for know friction between pile and soil. **Figure 10** looked about experimental research pull-out pile foundation.

4. Test result

The **Figure 11** is the chart which shows that density occured increase of significient with the variated voltage of electricity. More the voltage electricity increase, water content are decrease. While density of soil are increase. It caused the influence of anode and cathode into soil. The cathode can absorbsing moisture from soil and can be make the void increase. While anode given pulled from cathode. Then cathode can absorb the water in soil with on voltage.

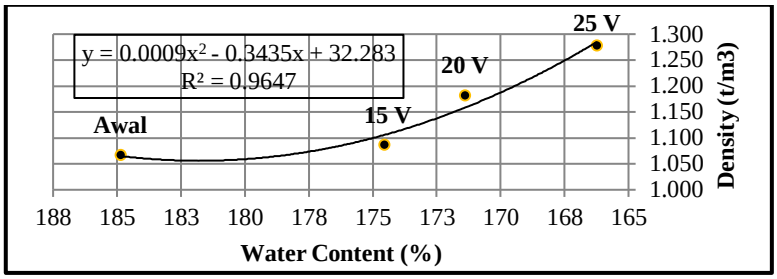

Figure 11. Graph of comparison between water content and density of electrokinetic peat soil.

To knows performance of peat soil mixed clamshell, so done the direct shear test on **Figure 12**. Peat soil mixed clamshell 4% content more have shear strength 0.2896 kg/cm2 from clamshell content other.

The direct shear test on unsoaked four days, clamshell 6% content more good effective the increase of shear strength than clamshell content other show in **Figure 13**.

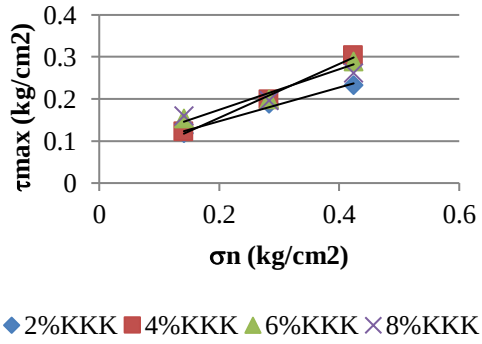

Figure 12. Graph of shear strength unsoaked for 0 day.

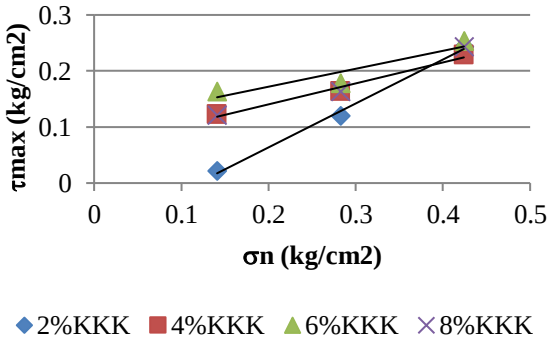

Figure 13. Graph of shear strength unsoaked for 4 day.

Based on the result in **Figure 14**, an extreme fast settlement occurred on the peat soil with small load which is not yet augmented with any compound material and electrokinetic. The settlement value by 87.16 mm with load capacity is about 0.36 kN. While 25V electrokinetic peat soil indicates that the peat experiences a tensile elevation of pile foundation about 7% on the peat soil without repairment. A settlement about 65.30 mm occurred and load capacity is about 0.48 kN. Furthermore, peat soil with clamshell compound and dielectrokinetic has major stress strength by 53% and a settlement by 67.23 mm. It verifies that peat soil with 8 & clamshell compound and 25V electrokinetic produces a better repairment to support the total ultimate bearing capacity of pile foundation in laboratory scale. Tensile test is being performed once again high the stress test of pile foundation. From the result, friction value of pile foundation and the peat soil can be identified (**Figure 15**). The tensile test result is shown in figure 15 below.

From the testing result of pile foundation tensile force, it is revealed that electrokinetic peat soil produces a large tensile force. Peak-load of tensile on 25V electrokinetic peat soil is 1.8 kN. While foundation of compound peat soil with 8% clamshell and 25V electrokinetic demonstrates a low tensile force. It is resulted from high fiber content of peat soil that is capable to knot the planted pile foundation and electrokinetic that may support the improvement of tensile force on peat soil pile foundation.

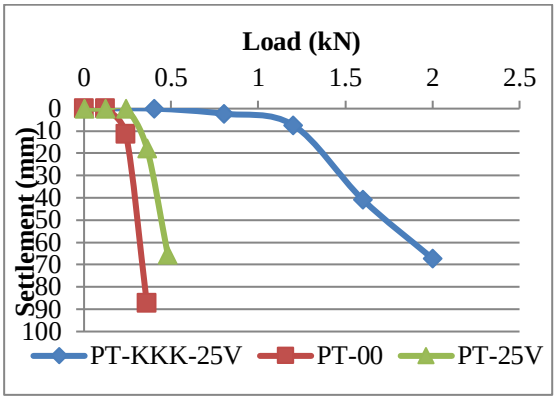

Figure 14. Graph static loading of pile foundation.

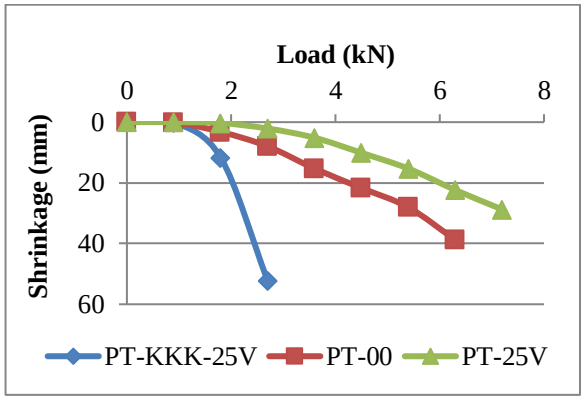

Figure 15. Graph pull-out test of pile foundation.

5. Conclusion

Based on the result, it concludes that:

- Apparently, pile foundation on peat soil have low bearing capacity of 0.36 kN. Because the peat soil is soft soil, it doesn't adhesive, void ratio is large and high water content.
- Ultimate bearing capacity of pile foundation is existed on mixed soil with 8% clamshell and 25V on electrokinetic. It is caused from the clamshell. That influenced during by binding mass of clamshell on the peat soil. Then electrokinetic is able to reduce the water content of soil and decrease the void on peat soil.
- For friction bearing capacity of pile foundation which capable to bear a high tensile force is pile foundation with 25 V on electrokinetic. Its caused that have fiber content of the peat soil. So, the peat soil is able to bear a high tensile force. Then electrokinetic can reduce void on peat soil.

Acknowledgement

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