Analysis of the Influence of the Use of Palm Oil Fuel Ash (POFA) and Lime against Unconfined Compressive Strength Value on Clay

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Abstract: Unconfined Compression Test is one of the parameters needed to determine the shear strength of the soil. Unconfined Compressive Test in the laboratory is performed on original and remoulded soil samples. Soil is one of the materials used in the construction. However, not all soils can be used as construction materials. Therefore, it is necessary to improve the properties of the clay soil that meet the technical requirements and parameters. One of the efforts made is by soil stabilization method. This study will discuss the stabilization of clay soil with the addition of lime and Palm Oil Fuel Ash (POFA) as stabilizer material which is expected to improve the physical and mechanical properties which will be observed with Unconfined Compression Test (UCT) to obtain a clay soil that meets the technical requirements of use on construction field. The mixture combinations which will be used in this research are 2%-12% of POFA, 4% and 6% of lime. From the test of index properties for the original soil has 34.43% of water content; 2.65 of specific weight; 47.33% of liquid limit; and 29.88% of plastic index, this soil is included in the group of CL (clay – low) and this soil could be classified as type of soil A7-6. The CBR value for unsoaked original soil is 6.29%. Meanwhile the optimum CBR value for all mixture variations of unsoaked soil is obtained in the mixture of 4% lime and 12% POFA which is equal to 9.48% and the optimum unconfined compressive strength also obtained from the same mixture which is equal to 3,908 kg/cm^2.

1 INTRODUCTION

The soil consists of three components, they are water, air, and solid materials. Air is considered to have no technical effect, meanwhile water significantly affects the engineering properties of soil. The cavity between the grains can be partially or completely filled by water or air. When the cavity is completely filled with water, the soil will become partially saturated. Water content is expressed in percent, where the transition from solid to semi-solid state is defined as the shrinkage limit. The water content in which the transition from a semi-solid state to a plastic state occurs is called the plastic limit, and from the plastic state to the liquid state is called the liquid limit. These limits are also known as Atterberg limits.

Clay has some distinctive characteristics, which are, in a dry condition it will be hard, in a wet condition it will be plastic and cohesive, clay also expands and shrinks rapidly so that it will get a great volume change and it happens because of the influence of water. The shear strength of the soil will be decreased if the structure of the soil is disturbed. The volume of soil which has a lot of clays will change if the water content changes. The level of expanding generally depends on several factors, they are the type and amount of minerals present in the soil, water content, soil structure, salt concentration in pore water, cementation and the presence of organic materials.

Due to the unstable clay properties, stabilization is required in order to increase the soil bearing capacity. Stabilization can be done with mixing the soil with another materials like cement, lime stone and others to increase engineering properties. The soil stabilization process involves mixing the soil with other soils to obtain the desired gradation, or mixing the soil with the manufactured materials so that the engineering properties will be better. Lime can be used as stabilizer with condition that the plasticity index of the soil has to less than or equal to 10%. The purposes of this research are to modify the soil properties, to improve the wet soil in order to make it can be used, to decrease the plasticity so that the materials will get more stable, and to increase

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the bearing capacity of clay. The palm oil industry produces solid waste such as fibers, shells and empty bunches. Palm bunches contain lime (CaO) and silica that has the potential to be used as stabilizers.

The previous research (2017) on the stabilization using lime obtained a result that lime mixture with a mixture of 10% lime gave an optimum CBR value of 8.75%. Farras Nazwa (2017) conducted a study on the stabilization using cement, lime and gypsum with Unconfined Compression Test (UCT) and obtained a result that lime mixture with a mixture of 10% lime gave a maximum compressive strength (q_u) of 3.307 gr/cm^2.

2 METHOD

In this research, the materials that we used are clay, lime, and POFA. Soil samples used in this study were taken from PTPN II, Patumbak, Deli Serdang, North Sumatra. The lime which is used is dry lime bought from the store. Then the lime was filtered using a sieve no. 200. The POFA used in this study was taken from PT. London Sumatera, Tanjung Morawa, North Sumatera.

2.1 Experimental Apparatus

The equipments used in this research are the tools for Water Content Test, Specific Gravity Test, Atterberg Limit Test, Compression Test, Unconfined Compression Test, and other tools in Soil Mechanics Laboratory, Faculty of Engineering, Universitas Sumatera Utara

2.2 Manufacture of Specimens

The sample was divided into two parts: the original soil sample without lime and the POFA and samples with the mixture of lime and POFA, as for the percentage mixture of POFA are 2%, 3%, 4%, 5%, 6%, 7%, 8% , 9%, 10%, 11%, 12% and for lime are 4% and 6%, with curing time for 7 days.

2.3 Sample Testing

Tests for the original soil include: Water Content Test, Specific Gravity Test, Atterberg Limits Test, Sieve Analysis Test, Compaction Test, Unconfined Compression Test

The tests for soils that have been mixed with POFA and lime include: Atterberg Limits Test, Compaction Test, Unconfined Compression Test.

2.4 Data Analysis

Analyzing the data is done after the whole sample has been tested and analyzed. Test results can be graphs and tables. The flowchart is show in Figure 1.

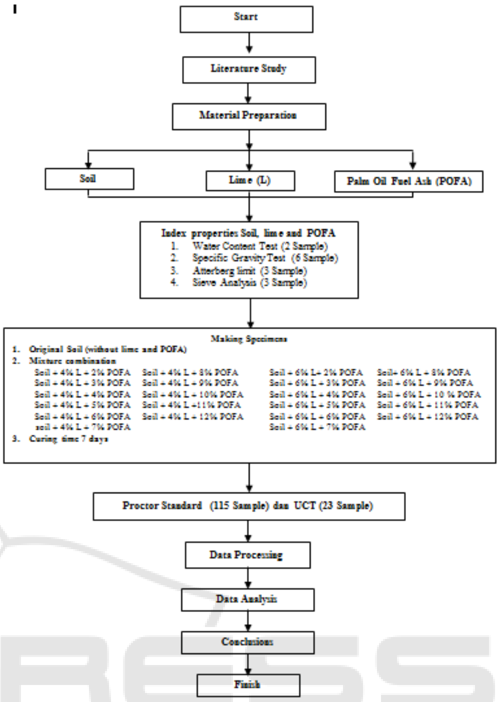

Figure 1: Research Flow Chart

3 RESULT AND DISCUSSIONS

The results will be discussed in three subsections, they are physical properties, soil mechanics with stabilizer, and engineering properties (Proctor Standard and of Unconfined Compression Test).

3.1 Physical Properties of Soil

The results of testing the physical properties of soil can be seen in Table 1 below.

Table 1: Result of Physical Properties

No.	Data	Soil	POFA	Lime
1	*Water Content*	34.43 %	-	-
2	*Specific Gravity*	2. 6537	2.5744	2.59
3	*Liquid Limit*	47.33 %	Non - plastic	Non - plastic

4	*Plastic Limit*	17.45 %	Non - plastic	Non - plastic
5	*Plasticity Index*	29.88 %	Non - plastic	Non - plastic
6	Sieve Analysis	51.38 %	75.91%	30.05%

From the data above obtained that the percentage of soil passed the sieve no.200 is 51.38% with liquid limit 47.33% and index plasticity 29.88%. Based on the AASHTO soil classification, for the percentage of passing the sieve no. 200 minimum 36%, has a liquid limit of at least 41% and a plasticity index value of at least 11% then the soil samples can be classified in soil type A-7-6. Based on soil classification according to USCS, which obtained liquid limit value of 47.33% with plasticity index value of 29.88%, soil samples are included in Clay Low.

Table 2: Chemical Composition of POFA and Lime.

No.	Chemical Compounds	POFA (%)	Lime (%)
1	Silica (S_iO_2)	67.4	3.03%
2	Calcium oxide (CaO)	1.542	51.8%
3	Magnesium oxide (MgO)	3.024	0.81%
4	Iron(III) oxide (Fe_2O_3)	0.001	0.4%
5	Aluminium oxide (Al_2O_3)	10.999	1.53%

3.2 Soil Mechanic with Stabilizer

Atterberg Limit test results for the original soil and soil stabilizer are shown in Figure2, Figure 3, and Figure 4.

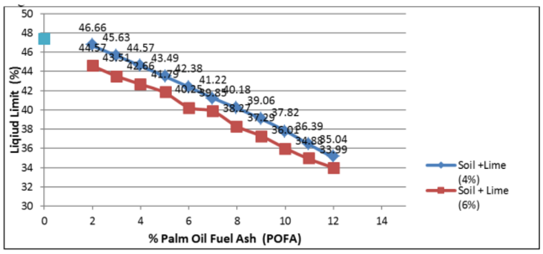

Figure 2: Graph of liquid limit with percentage variations of POFA.

The results show that the liquid limit of the original soil is equal to 47.33% and the lowest liquid limit value obtained from the addition of 6% lime + 12% POFA with 7 days of curing time is equal to 33.99%. It can be seen that the liquid limit has decreased due to the addition of lime and POFA. The greater the percentage of the addition of POFA and lime, the smaller the liquid limit.

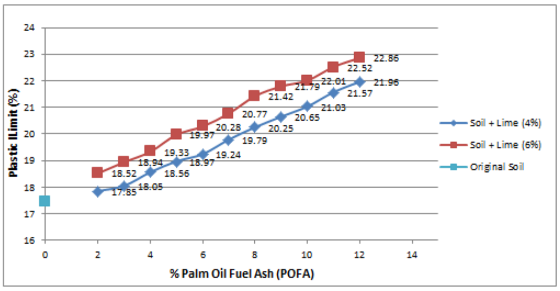

Figure 3: Graph of plastic limit with percentage variations of POFA.

Figure 3 shows an increase in the plastic limit value due to the addition of lime and POFA. The plastic limit is 17.45% to soil and continues to increase until the highest plastic limit value in the 6% Lime + 12% POFA of 22.86%. The greater the percentage of the addition of POFA and lime, the higher the plastic limit.

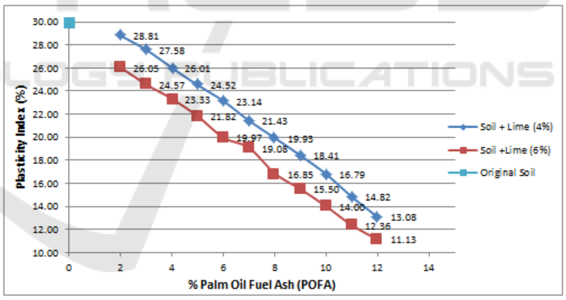

Figure 4: Graph of plasticity index with percentage variations of POFA.

Figure 4 describes decrease in the plasticity index value due to the addition of lime and POFA. Swelling on the soil can be reduced if the plasticity index value is low. The addition of POFA can increase the attachment of soil particles so that the granules formed are more stable and harder. If the POFA and limestone are used together, the silica contained in the POFA can cover the soil pores and the soil will be more resistant to water, resulting in a decrease in the plastic properties of the soil [1]. The decrease in plasticity index is relatively large, namely from 28.88% to 11.13% in the variation of

6% limestone + 12% POFA mixture in curing time 7 days.

3.3 Unconfined Compression Test (UCT)

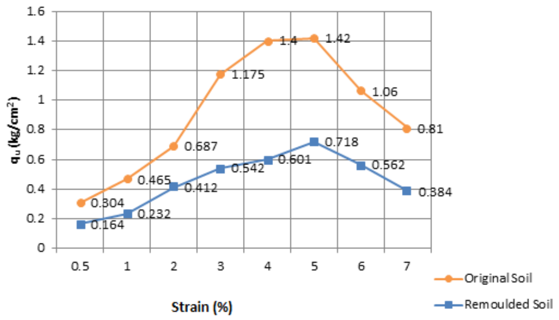

Figure 5: Graph of Relation of Soil Compressive Strength (q_u) and Strain on Original and Remoulded Soil

Figure 5 tells the compressive strength value for the original soil of 1.42 kg / cm² and for remoulded soil 0.718 kg / cm². The decrease will occur if the maximum compressive strength value has been reached. The decline occurred due to damage to the structure of the soil received on remoulded soil. Soil damage due to reduced soil strength is called sensitivity.

$$Sensitivity = \frac{q_u\ undisturbed}{q_u\ remoulded} = \frac{1{,}42}{0.718} = 1.97 \quad (1)$$

The soil sample used in this study has a sensitivity ratio of 1.97. So, it is classified into low sensitivity soil. That is, the structural damage experienced by the soil does not have a big effect on the change of compressive strength or the shear strength of the soil. Clay with low sensitivity do not lose much of their structural strength after they have been disrupted in their original order or after remoulded. The higher the sensitivity value of the soil, the larger the change to the parameters of its strength when it receives a disturbance.

Figure 6 below that the strength of original soil (q_u) is 1.42 kg/cm^2. Then, the unconfined compressive strength keeps increasing along with the addition of lime and POFA. The maximum unconfined compressive strength is obtained from the addition of 6% lime + 12% POFA that is equal to 3.908 kg/cm^2.

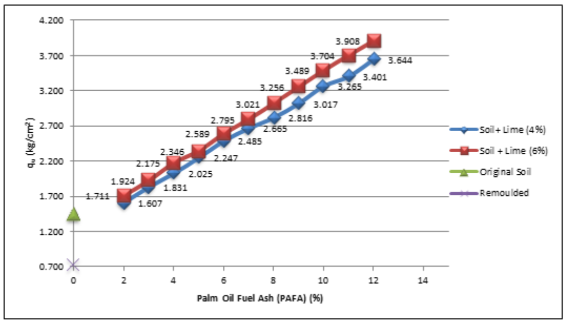

Figure 6: Graph between Unconfined Compression Strenght (qu) with mixed variation of Lime and POFA addition

Thus, the more the addition of lime and POFA will result in greater compressive Strength of soil. This is because the percentage of addition of lime and POFA in this study is still classified in the addition of an effective stabilizer.

4 CONCLUSIONS

1. The optimums CBR obtained on the addition of 4% Lime + 12% POFA and 6% Lime + 12% POFA which are 8.98% and 9.48%.
2. The maximum compressive strength are obtained on the addition of 4% Lime + 12% POFA and 6% Lime + 12% POFA with compressive strength which are equal to 3.644 kg/cm^2 and 3.908 kg/cm².
3. Along with the addition of stabilizer materials with different percentages, there is a decrease in the value of PI on the soil which means the soil becomes more stable.
4. Increasing the value of the maximum dry weight (γd_{max}) causes a decrease in the optimum water content (w_{opt}).
5. CBR values obtained with the addition of stabilizers in the form of lime and POFA increase as the amount of mixture of the stabilizer material increases.
6. The unconfined compressive strength (q_u) and Cu obtained from the unconfined compression test are increasing as the amount of mixture of the stabilizer material increases.

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REFERENCES

Bowles, J.E., 1989, *Sifat-Sifat Fisis dan Geoteknik Tanah* (*Mekanika Tanah*), Jakarta: Erlangga.

Hardiyatmo, H C 2010 *Mekanika Tanah 1* (Yogyakarta: Gadjah Mada University Press)

Ronny Hutahuruk, 2016 *Stabilisasi Tanah lempung dengan menggunakan abu Vulkanik di tinjau dari Nilai Unconfined Compression Test (UCT)* (Medan: Program Studi Teknik Sipil Universitas Sumatera Utara.

Refi, Ahmad, dkk. 2015. *Pengaruh Variasi Abu Sawit Terhadap Kembang Susut Tanah Lempung*. Padang: Insitut Teknologi Padang.

Warsiti. 2009. *Meningkatkan CBR dan Memperkecil Swelling Tanah Sub Grade Dengan Metode Stabilisasi Tanah dan kapur*. Semarang: Politeknik Negeri Semarang.

Ika Puji Hastuty, Roesyanto, and Jeriko A 2017 *Study of the Effectiveness of the Use of Cement and Bottom Ash Towards The Stability of Clay in Term of UCT Value* Science Direct Procedia Engineering 171, 484 – 491.