Peat Stabilization with Carbide Lime

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Abstract

Peat is in the category of problematic soil because it has low shear strength and high compressibility, which are not suitable for construction. Peat lands can be found in various parts of the world; therefore, it is essential to find an alternative to improve the strength since nowadays lands are very expensive and very limited. This paper presents a research on peat stabilization with objectives that are to improve the soil to be more stable and to have higher strength and to find a cheap alternative material that can be used as a stabilizing agent. In this research, an admixture, which is carbide lime, a by-product of acetylene is used to stabilize the peat soil. Laboratory tests on physical properties and shear strength are done. The research is done on peat soil that is collected from Matang area in Kuching, Sarawak. Investigation on the effects of various percentages of carbide lime added to the soil at different curing time on the soil strength is performed. The changes in strength gained are also compared with the natural soil sample. The unconfined compressive strength test results are analyzed and show that, with the increase of percentages of carbide lime added and the increase of curing time, the strength of the peat soil sample is increased.

***Keywords*:** Peat stabilization, carbide lime, unconfined compressive strength

1. INTRODUCTION

Stabilization of soil is one of the most important criteria that should be considered for construction on soft soil. It is well known that stability of ground will affect the stability of the structure above it and there are many types of soil to deal with, depending on the area, its location, its surroundings and various other factors. Peat soil is an extremely soft soil and often referred to as problematic soil by engineers. Peat soil is not only soft, it is compressible too where this characteristic will lead to excessive settlement which is a very serious problem. There are about 2.7 million ha of peat and organic soils in Malaysia accounting for about 8% of the total land area of the country. In Sarawak, peat lands are in abundance and Sarawak has the largest area of peat in the country, covering about 1.66 million ha and constituting 13% of the state [1]. Today, lands are very expensive and very limited and due to this, constructions on peat soil cannot be avoided. Maintenance works on damages caused by peat soil would be the next arising problem if matters are not resolved and this can affect the safety of the occupants and can be costly. There are many researches on improving peat soil. The methods are mostly concentrating on modifying and stabilizing the soil. Stabilization of peat soil focuses on increasing the strength of this soft and highly compressible soil. It is done to improve the ability of the soil to perform well by increasing its strength and decreasing the excessive settlement when soil is subjected to loads. According to Jarrett (1997), peat soils experience instability and massive primary and long term consolidation settlements when subjected to even moderate load increases [2].

There are various methods of stabilization and one of them is using admixture. Different types of admixtures are available. Chemical admixtures or chemical stabilization always involve treatment of the soil with some kind of chemical compound, which when added to the soil, would result in a chemical reaction. The chemical reaction modifies or enhances the physical and engineering aspects of a soil, such as, volume stability and strength [3]. Replacing peat with good quality soil is still a common practice when construction has to take place on peat deposit even though most probably, this effort will lead to uneconomical design because it requires transportation of large amount of good quality soil. Hence, cheaper alternatives or cheaper improvement method is to be found. An admixture, which is carbide lime, a by-product of acetylene, and a stabilizer, is used in this research of peat soil stabilization.

2. OBJECTIVES OF THE RESEARCH

The main aim of conducting this study is to do stabilization of peat using admixture which is carbide lime. The specific objectives of this study are to stabilize peat soil and to improve the strength of peat soil.

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3. EXPERIMENTAL WORK

The peat soil samples used in this study were collected from Matang area at a depth of approximately 0.25m – 0 .30m below the ground surface. The laboratory works are divided into two categories, which are laboratory works that determine physical and compaction properties, and laboratory works, which test the strength of the peat soil. The former laboratory works are particle size analysis (sieve analysis), moisture content, degree of decomposition, specific gravity, compaction test (Standard Proctor Test) and organic, fiber and ash content. For the latter laboratory works, samples were oven dried, grinded and the samples passing sieve size 1.18mm were used for testing and mixing. Unconfined compressive strength test (UCS) was done to test the strength gained and to make strength comparison between peat soil without carbide lime and peat soil with different percentages of carbide lime, which are 3%, 6%, 9%, and 12% of total mixing weight. This test was conducted on the soil sample after curing period of 7, 14, and 28 days.

4. RESULTS AND DISCUSSION

Particle size analysis

Particle size analysis was done on both peat soil and carbide lime used in this study. The size distributions of peat soil particle and carbide lime particle that will be used in the mixing are analyzed. It is found that the distribution for Carbide Lime is similar to peat distribution for the same range of sieve size. No further hydrometer testing was performed on Carbide Lime as it is feared that hazardous reaction might occur with the reagent used for the hydrometer test. However, it was observed about 3.05 g of Carbide Lime passed through the smallest sieve size.

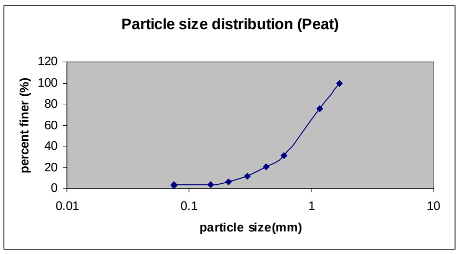

Figure 1 Particle size distribution of peat soil

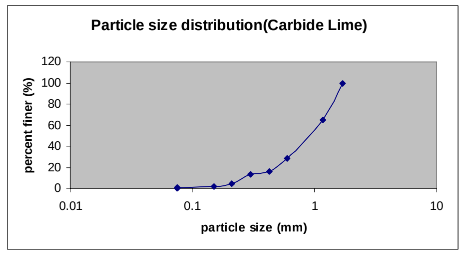

Figure 2 Particle size analysis of Carbide Lime

Moisture Content

There are three soil samples taken which are from the surface, middle and bottom parts respectively for 0.25-0.30 m depth. Each sample was prepared for three sets and average value was determined. The first collection results indicate that the moisture content increases proportional to the soil depth. Moisture content of soil for the first collection is higher for the second collection. This is because it was raining during the collection and the water table was high.
Carbide Lime sample was collected from Eastern Oxygen Sdn. Bhd. factory. The carbide lime collected was in slurry form and the moisture content of it is 86.18%.

Table 1 Moisture content of soil (First collection)

Sample	Surface	Middle	Bottom
Moisture content (%)	472.99	517.50	785.87
Average Moisture content (%)	592.12		

Table 2 Moisture content of soil (Second collection)

Sample	Surface	Middle	Bottom
Moisture content (%)	415.54	393.40	529.21
Average Moisture content (%)	446.05		

Table 3 Moisture content of Carbide Lime

Sample	1	2	3
Moisture content (%)	84.17	86.00	88.38
Average Moisture content (%)	86.18		

Degree of Decomposition

Degree of decomposition of the soil is the measure of the organic remains that have decayed. Degree of decomposition of peat soil was done by referring to the Von Post scale that consists of 10 scales that are H1 to H10. In this study, the soil collected in Matang falls in the category of H5 and H6 that is hemic or moderately decomposed.

Specific Gravity Test

The specific gravity (G_s) of the highly organic or peat soil was determined based on the procedure stated in BS 1377: Part 2: 1990 [4]. In this test, specific gravity was measured using small pyknometer. For maintaining accuracy, the average specific gravity is obtained from the results of three tests. The soil must be heated to avoid entrapped air that will affect the results because of the test sensitivity. Two tests were done that is specific gravity (not heated) and specific gravity (heated) for comparison purpose. From the results, it can be concluded that the sample must be heated in order to obtain more accurate results.

Table 4 Specific Gravity (not heated)

Sample	1	2	3
Specific gravity	0.85	0.76	0.92
Average Specific gravity		0.84	

Table 5 Specific Gravity (heated)

Sample	1	2	3
Specific gravity	1.45	1.39	1.38
Average Specific gravity		1.41	

Compaction (Standard Proctor Test)

Compaction test or Standard Proctor test was conducted by referring to BS 1377-1990: Part 4 [4]. This is done to determine the maximum dry density (MDD) (γ_d) and the optimum moisture content (OMC) of the peat soil sample that will be used in the mixing. This test was done in three sets. The first test results could not give the expected dry density-moisture content curve. The problem was the soil used during compaction test was not totally dried. To overcome this problem, the soil was dried under the sun for 3 days until it was totally dried and the compaction test was repeated. In the first compaction test, particles larger than 1.18 mm were removed before testing.

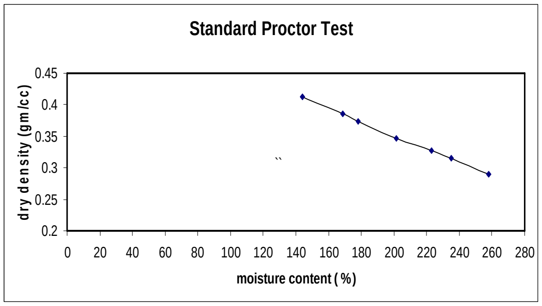

Figure 3 Standard Proctor Test 1

The second compaction used bigger particle size that was 6.3mm. Assumption was made in which it could give similar results as testing 1.18mm particle size as the soil used was taken from the same location. The maximum dry density from the second compaction is 0.56gm/cc and the optimum moisture content is 80% (Figure 4).
The third compaction effort used soil particles passing 1.18mm sieve. The maximum dry density from the third compaction is 0.51gm/cc and the optimum moisture content is 82% (Figure 5). The results of the second and the third compaction results do not differ much but for more accurate mixing, the third compaction results is used as the particle size that will be used in the mixing for shear strength test is of <1.18mm.

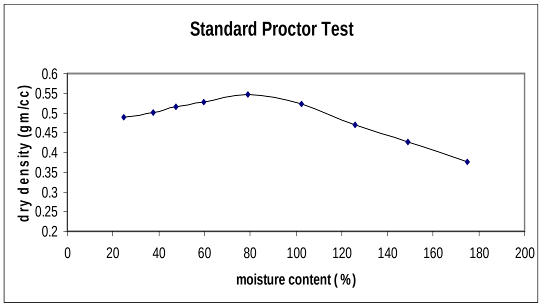

Figure 4 Standard Proctor Test 2

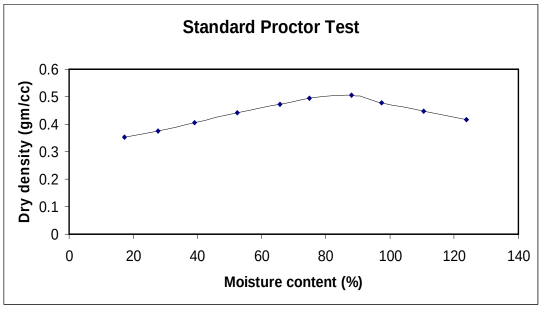

Figure 5 Standard Proctor Test 3

Organic, fibers and ash content

Organic content of the soil sample depends on the ash content. Organic content is inversely proportional to ash content. Ash content (as measured by test methods D2974 [5]):

- Low ash – Peat with less than 5% ash
- Medium ash – Peat with between 5 and 15% ash
- High ash – Peat with more than 15% ash

Table 6 Ash content, loss in ignition and organic content (1 hour in muffle furnace)

Sample	Surface	Middle	Bottom	Average
Ash content (%)	12.27	9.12	6.52	9.30
Loss on ignition (%)	87.70	90.90	93.50	90.70
Organic Content (%)	87.20	90.50	93.20	90.30

Table 7 Ash content, loss in ignition and organic content (5 hours in muffle furnace)

Sample	Surface	Middle	Bottom	Average
Ash content (%)	20.56	27.42	22.04	23.34
Loss on ignition (%)	79.40	72.60	78.00	76.66
Organic Content (%)	78.60	71.50	77.10	75.73

Table 6 shows the results of ash content, loss in ignition and organic content (1 hour in muffle furnace) and Table 7 shows the results of ash content, loss in ignition and organic content (5 hour in muffle furnace). The results of 5 hours in muffle furnace is more accurate since the heating duration is longer and the soil was totally ashed compared to the results of 1 hour in muffle furnace in which some of the soil was only partially ashed. This can be known by comparing the soil color after the soil sample is taken out from the muffle furnace.

The fiber content is the dry weight of fibers retained on ASTM sieve no. 100 (>0.15 mm opening size) as a percentage of oven dried mass (ASTM D1997) [6]. The first fiber content test was done by dry sieving on 425µm sieve. From this test, the fiber content is 80.27%.The second fiber content test was conducted by wet sieving the soil sample on sieve no. 100 (>0.15 mm opening size). From this test, the fiber content is 25%.The second fiber content test result is used in order to obtain more accurate result in which the soil was wetted in order to further break the soil particles into smaller size.

Unconfined compressive strength

There were 2 mixing done for the same type of soil (particle sizes < 1.18mm) and percentage of lime. Mixing 1 is not as good as Mixing 2 because the sample taken out from the pipe was not as perfect and smooth as samples in Mixing 2. Some of the soil surface was peeled off, retained on the pipe because of excessive used of grease. There were 3 layers of compacted soil prepared in the sample. After the first layer had been compacted, another layer was placed and this was repeated until the final layer.

Table 8 Results of Unconfined Compressive Strength Test of Soil Before Stabilized

Sample (0% Lime)	1	2	Average
Unconfined Compressive Strength (kPa)	38.33	38.33	38.33

From Table 8, it can be noticed that the unconfined compressive strength of soil before stabilized or before adding Carbide Lime is 38.33 kPa. Table 9 shows the results of unconfined compressive strength test of Mixing 1 that is in average value. From the values, it can be seen that strength is gained after stabilization. The longer the curing time, the higher strength gained. For sample of 7 days and 14 days curing, 3% and 6% lime added shows increment of strength but the strength decreases in the 9% lime added and it increases again in 12% lime added. For sample of 28 days, percentage lime added is directly proportional to the strength gained. Figure 6 shows the results of unconfined compressive strength test of Mixing 1. From the plot it can be concluded that with the increase of different percentages of carbide lime added, and with the increase in curing periods, the strength of the original soil is increased.

Table 9 Results of Unconfined Compressive Strength Test of Mixing 1

Percentage Lime (%)	**Unconfined Compressive Strength (kPa)**		
	Curing Time (days)		
	7	14	28
3	42.58	54.10	60.63
6	50.23	66.66	63.81
9	41.89	60.38	73.36
12	51.79	62.15	74.50

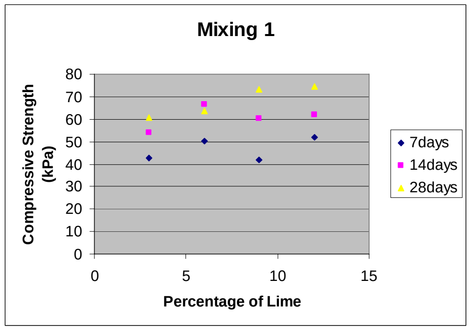

Figure 6 Results of Unconfined Compressive Strength Test of Mixing 1

Table 10 shows the results of unconfined compressive strength test of Mixing 2. Mixing 2 was cured up to 14 days. From the results, it can be seen that there is gain in strength. Strength gained for sample cured for 14 days is higher than the sample cured for 7 days. Strength increases with the increase of carbide lime added but there is a little bit of decrease for the 12% lime added sample. Figure 7 shows the same trend with Figure 6 at which strength is increased by time and by increment of lime percentage. Mixing 2 shows higher value of strength because the condition of the sample before testing was good and none of the surface was peeled off or remained on the pipe.

Table 10 Results of Unconfined Compressive Strength Test of Mixing 2

Percentage Lime (%)	**Unconfined Compressive Strength (kPa)**	
	Curing Time (days)	
	7	14
3	72.32	86.94
6	76.2	114.8
9	90.93	123.45
12	89.03	115.30

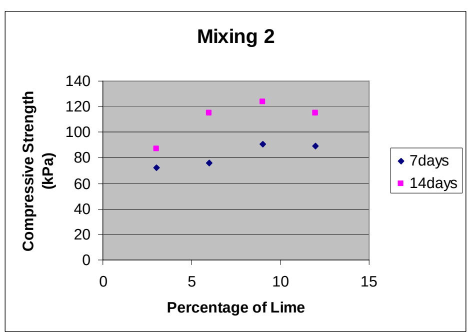

Figure 7 Results of Unconfined Compressive Strength Test of Mixing 2

5. CONCLUSIONS

The main observations and findings are concluded as follows:

- Soil collected from Matang area falls in the category of H5 and H6, that is, hemic or moderately decomposed.
- Moisture content of peat soil is very high and the moisture of the soil used in this research that is collected in Matang area falls in the range of 400% to 600% for the depth of 0.25 to 0.3m.
- The unconfined compressive strength test results shows that with the increase of percentages of carbide lime added, the strength of the peat soil sample is increased.
- The unconfined compressive strength test results shows that with the increase curing time, the strength of the peat soil sample is increased.
- Carbide Lime that is a by-product of acetylene can be used as a stabilizer since it can increase the strength of the peat soil when added to the soil.

6. ACKNOWLEDGMENT

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