Stabilization of Peat Soil Using Ordinary Portland Cement and Fiber Polypropylene

by

Nor Sa'adah Bt Abdul Salam

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Bandar Seri Iskandar

31750 Tronoh

Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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Civil Engineering Programme
Universiti Teknologi PETRONAS
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Approved by.

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(Dr. Syed Baharom Bin Syed Azahar)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

September 2012

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the reference and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

NOR SA'ADAH BINTI ABDUL SALAM

ABSTRACT

Peat soil normally occurs at surfaces that are basic parts of the wetland systems that found as extremely soft and unconsolidated deposits. The main problem of this soil has known cause by its high compressibility and low shear strength. Construction on peat soil has proven to be a challenging task to civil engineers because of its characteristics. Geotechnical risks and costs frequently accompanied to be higher when doing construction on soft soil likes peat. This study aims to determine the effectiveness the use of Ordinary Portland Cement (OPC) with fiber polypropylene to strengthen and stabilized the peat soil. It will be proved with the implementation of Unconfined Compressive Strength (UCS) test and curing time. Further, UCS test is used to reach mechanical properties of fine grained soil and fiber were used as it characteristic in prevent the formation of crack on loading and increasing the strength of the samples. This test will be done in different amount of OPC and curing time. For sample with OPC and without fiber, the amount of OPC used is 2%, 5% and 10%. However, for sample with OPC and fiber, the amount used is 2%, 3%, 4%, 5%, 6%, 7%, 8% and 10% together with 0.15% of fiber. All results from this sample will be compared with plain peat soil which is without any addictive. Apart from that, samples will go through curing process in air for 7 and 14 days before UCS test be done.

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TABLE OF CONTENT

CERTIFICATION…………………………………………………… i

ABSTRACT……………………………………………………….. iii

ACKNOWLEDGEMENT…………………………………………… iv

LIST OF FIGURE…………………………………………………. vi

LIST OF TABLE…………………………………………………. vii

CHAPTER1: INTRODUCTION

1.1 Background of Study…………………………………… 1
1.2 Problem Statement……………………………………… 3
1.3 Objectives and Scope of Study………………………… 3

CHAPTER 2: LITERATURE REVIEW

2.1 Development and Structure of Peat Soil………………. 4
2.2 Problem relating with peat soil………………………… 5
2.3 Curing method…………………………………………. 7
2.4 Fiber polypropylene and cement as stabilizer…………. 8
2.5 Unconfined Compressive Strength……………………. 9
2.6 Strength mechanism…………………………………… 11

CHAPTER 3: METHODOLOGY

3.1 Research Methodology………………………………... 12
3.2 Preliminary test……………………………………….. 14
3.2.1 Sieve analysis…………………………………. 14
3.2.2 Atterbergh limit………………………………. 15
3.2.3 Optimum moisture content…………………… 15
3.2.4 Organic content………………………………. 16
3.3 Test to stabilized peat soil……………………………. 16
3.3.1 Unconfined Compressive Strength…………… 16
3.3.2 pH test………………………………………… 17
3.4 Project activity………………………………………… 18

CHAPTER 4: RESULT AND DISCUSSION

4.1 Preliminary test……………………………………….. 19
4.2 Optimum moisture content…………………………… 20
4.3 Curing process………………………………………… 22
4.4 Unconfined Compressive Strength…………………… 27
4.5 Strength mechanism…………………………………... 30

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS
5.1 Conclusion…………………………………………….. 31
5.2 Recommendation……………………………………… 32

REFERENCES………………………………………………………… 43

LIST OF FIGURE

Figure 1.1	Peat soil in Peninsular Malaysia……………………………………..	2
Figure 2.1	Example of a highly-developed peat dome in the Baram Valley, Sarawak…………………………………………..	5
Figure 2.2	Air curing periods VS Water-cement ratio for stabilized peat soil samples containing different amount of cement………..	7
Figure 2.3	Fiber Polypropylene……………………………………………...	9
Figure 2.4	Ordinary Portland Cement………………………………………..	9
Figure 2.5	Unconfined Compressive Strength Test………………………….	10
Figure 3.1	Project planning…………………………………………………..	13
Figure 3.2	Sieve Analysis…………………………………………………….	14
Figure 3.3	Changes stage of soil behavior……………………………………	15
Figure 3.4	pH probe…………………………………………………………..	17
Figure 3.5	Gantt chart for FYP II………………………………………….....	18
Figure 4.1	Graphic plot of the moisture-density relation……………………..	21
Figure 4.2	Increase in strength with different amount of OPC and curing time……………………………………………………	23
Figure 4.3	Different percentage of OPC with0.15% fiber vs strength increase after days of curing………………………………………………..	28
Figure 4.4	Different percentage of OPC with0.15% fiber vs strength increase days of curing …………………………………………………..	29

LIST OF TABLE

Table 2.2	Typical peat properties………………………………………	6
Table 4.1	Properties of the peat soil……………………………………	19
Table 4.2	Determination of dry density and Optimum moisture content	20
Table 4.3	Strength obtained for 7 and 14 days curing period for different amount of OPC……………………………………………..	22
Table 4.4	Strength obtained for various amount of OPC with 0.15% fibers after curing period…………………………………...	27
Table 4.5	pH reading based on cement content………………………	30

ABBREVIATION

OPC	Ordinary Portland cement
UCS	Unconfined Compressive Strength
CBR	California Bearing Ratio
CSH	Calcium-Silicate-Hydrate
CAH	Calcium-Aluminate-Hydrates

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Peat soil is one of the softest organic soils. A variety of methods have been used in previous to stabilize peat soil deposits. Usually, civil engineers try to avoid construction projects on peat soils. There are many methods have been used previously such as remove and replaced peat soil with sand and silt or clay, load will be transfer to the deeper and suitable depth, distribute the load to the large area by cover the ground with synthetic materials for line construction and lastly they will used stabilization technique to strengthen the peat soil.

The method used previously by any means is mixing cement and silica or cement and lime. The most widely addictive that used to stabilize peat soil is ordinary Portland cement due to its strength. The addition of fiber polypropylene had given possible strength for these soils to increase. Thus, the study to improve peat strength is seemed to be important due to the increasing for construction project at this area.

For this study, it will start with test to determine index properties for plain peat soil which cements and fiber are not mix with the soil. Soil sample was collected from Hutan Melintang, Perak. The tests involved are sieve analysis, organic content, optimum moisture content and Atterberg limits. Then, sample of peat soil will evaluated using detailed test including unconfined compressive stress (UCS) and pH determination due to percent increase in OPC amount.

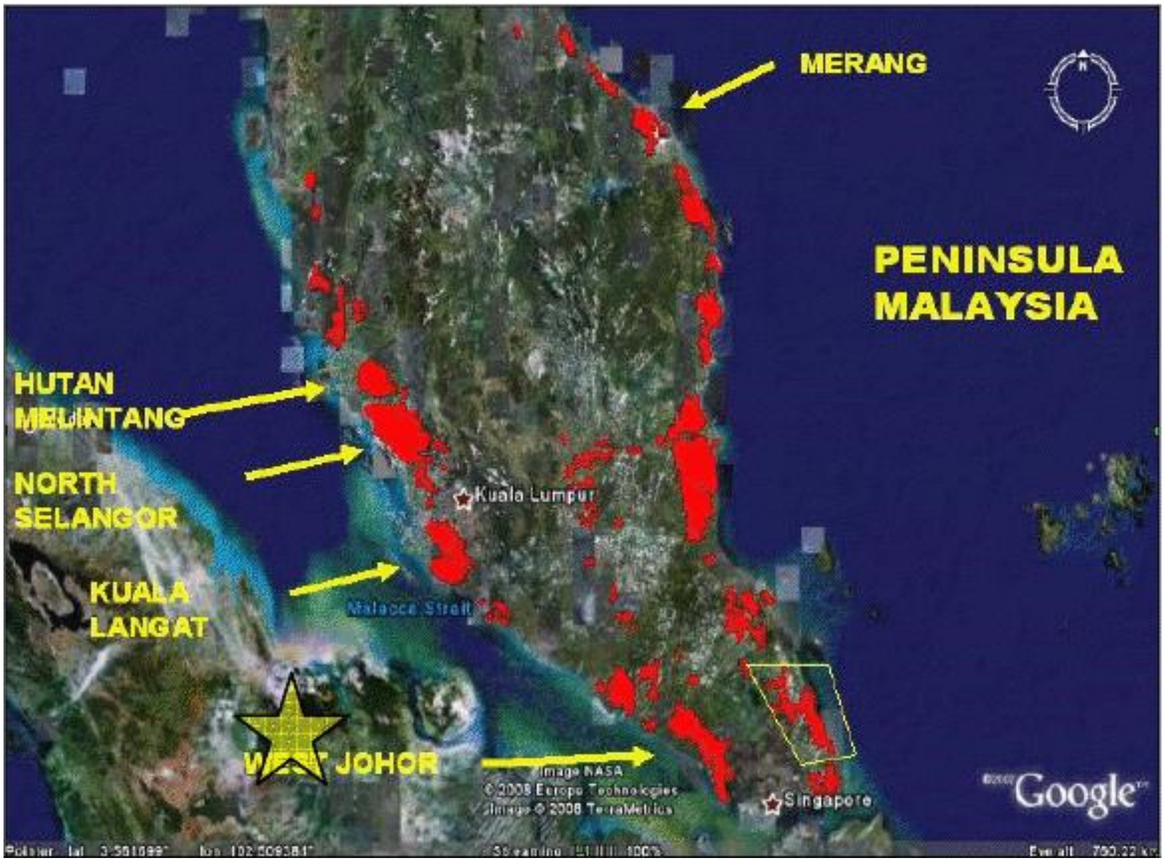


Figure 1.1: Peat soil in Peninsular Malaysia

Source: A quick scan of peatlands in Malaysia, Wetlands International-Malaysia, March 2010

UCS test are carried out with various amount of ordinary Portland cement with and without fiber polypropylene. Each set of samples consist of peat soil having optimum moisture contents with Ordinary Portland Cement (OPC) are 2%, 5%, and10% without fiber. Another set of samples will consist of OPC and fiber. The amount of OPC for this set is 2%, 3%, 4%, 5%, 6%, 7%, 8% and 10% together with 0.15% fiber. Then, all samples will be cured for 7 and 14 days in air before UCS test will be carried out.

1.2 PROBLEM STATEMENT

Peat soil normally occurs at surfaces that are basic parts of the wetland systems that found as extremely soft and unconsolidated deposits. The main problem of this soil knew cause by its high compressibility and low shear strength. This soil also has some settlement for every year. Therefore the study is needed to see whether Ordinary Portland Cement and fiber can increased strength and stabilize the peat soil.UCS test will be conducted and the data gathered to get the result of the peat strength. In addition, pH reading also will be carried out to determine the reaction and mechanism that strengthens the soil.

1.3 OBJECTIVE AND SCOPE OF STUDY

The objective of this study is to determine the effectiveness of Ordinary Portland Cement (OPC) and fiber either it can be used to strengthens and stabilize peat soil. In order to achieve the objective, a few researches and study need to be carried out by adding different amount of OPC into the peat soil together with fiber polypropylene. Then, pH reading is collected for each sample to determine the mechanism and reaction that leads to soil strength.

The strength and stabilization of peat soil will be analyzed by using UCS test and curing time. Curing process will be carried out for 7 and 14 days before UCS testing performed. Recommendations are made based on the percentage of cement and fiber mixed, curing process and pH reading.

CHAPTER 2

LITERATURE REVIEW

2.1 Development and Structure of Peat Soil

Most of the lowland peat lands in Malaysia have developed along the coast, behind accreting mangrove coastlines, where sulphides in mangrove mud and water restrict bacterial activity, leading to the accumulation of organic matter as peat. Many peat lands which are now far inland developed along the former coastline such that some may be around 100 km inland such as the peat areas around Marudi in Sarawak. The age of the oldest inland peat areas has been estimated as 4,000-5,000 years (N.Y Chik, 2010).

According to Wetland International-Malaysia report (2010), it is stated that peat soil is the composition of decomposed organic matter that has accumulated in a moist environment. This involved humification process where organic material decay into peat, which is partially brought by micro-organism. Area of abundance water also leads to peat formation and because lack of oxygen, decomposition of the organic is incomplete.

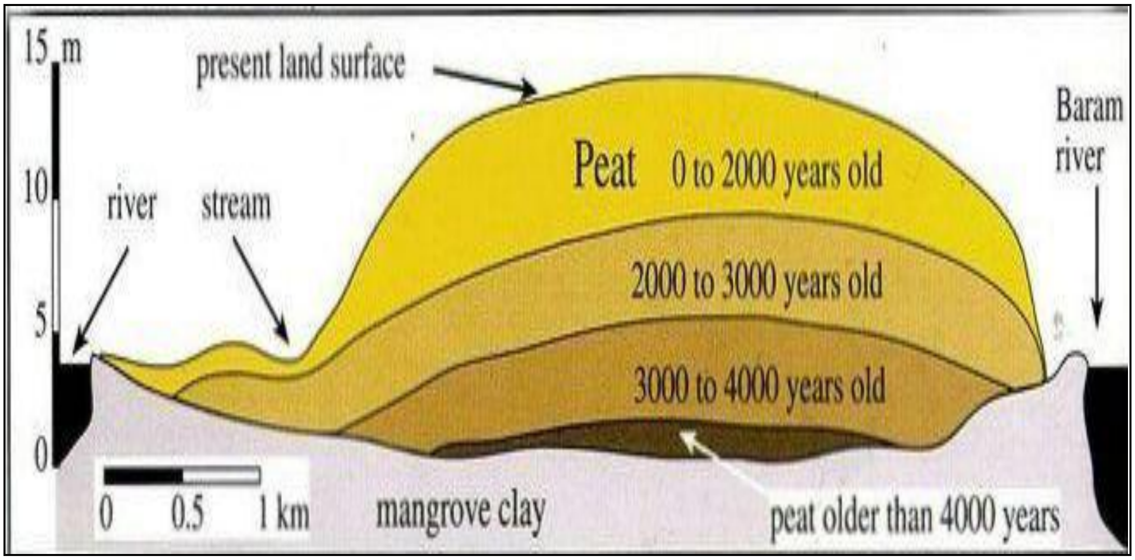


Figure 2.1: Example of a highly-developed peat dome in the Baram Valley, Sarawak.

Source: A quick scan of peatlands in Malaysia, Wetlands International-Malaysia, March 2010.

2.2 Problem relating with peat soil

There are numerous examples of abandoned areas in Malaysia can be found caused by peat soil. This is because peat soil area normally has unconsolidated surface deposit, loose and high in water table. Because of these problems, many developers avoid to have constructions in this area as it will be costly. Peat is considered to fall into 3 main groups for engineering purposes which are amorphous-granular peat, fine fibrous peat and course fibrous peat (Radforth, 1969). Amorphous-granular peats have high colloidal mineral content and are liable to hold its water locked in an adsorbed state around the grain structure, for example is clay. The two fibrous peats which are fine-fibrous and course-fibrous are woodier and hold most of its water within the peat mass as free water. These types of peat basically reflect the peat deposit grew and govern the main engineering properties.

Property	Type of Peat		
	Fibrous peat	Medium decayed peat	Decayed peat
Water content %	1400 - 2500	900 - 1400	500 - 900
Ash content %	1.5 - 3.0	3 - 8	8 - 30
Void ratio	22 - 40	13 - 22	9 - 13
Shear strength (kPa)	5-15	5-15	5-15
Permeability (cm/sec)	10^{-3} - 10^{-4}	10^{-4} - 10^{-5}	10^{-5} - 10^{-6}
Insitu bulk density (kg/m^3)	900 – 1100	900 - 1100	900 - 1100

Table 2.2: Typical peat properties

Source: Managing Peat Related Problem on Low Volume Roads, Ron Munro&Frank Mac Culloch, July 2009

2.3 Curing Method

In order to cure the stabilized peatsoil samples with cement and polypropylene fibers, aircuring technique described elsewhere has been used.In this technique, the stabilized peat soil samples forCBR tests were kept in normal room temperature of 30±2°C and relative humidity of 80±5% without anyaddition of water from outside. This technique is usedto strengthen the stabilized peat soil samples by gradualmoisture content reduction, instead of the usual watercuring technique or moist curing method which hasbeen a common practice in the past for stabilized peatsoil mixed with cement (Axelsson, 2002; Duraisamy,2006).

The air curing technique of peat soil stabilized withcement and polypropylene fibers increased the generalrating of the *in situ* peat soil from very poor (CBR from0-3%) to fair and good (CBR from 7 to above 20%)(Bowles, 1978).

It is stated that peat soil has very high natural water content and has sufficient water for curing process and does not need more water during curing process to stabilize peat.

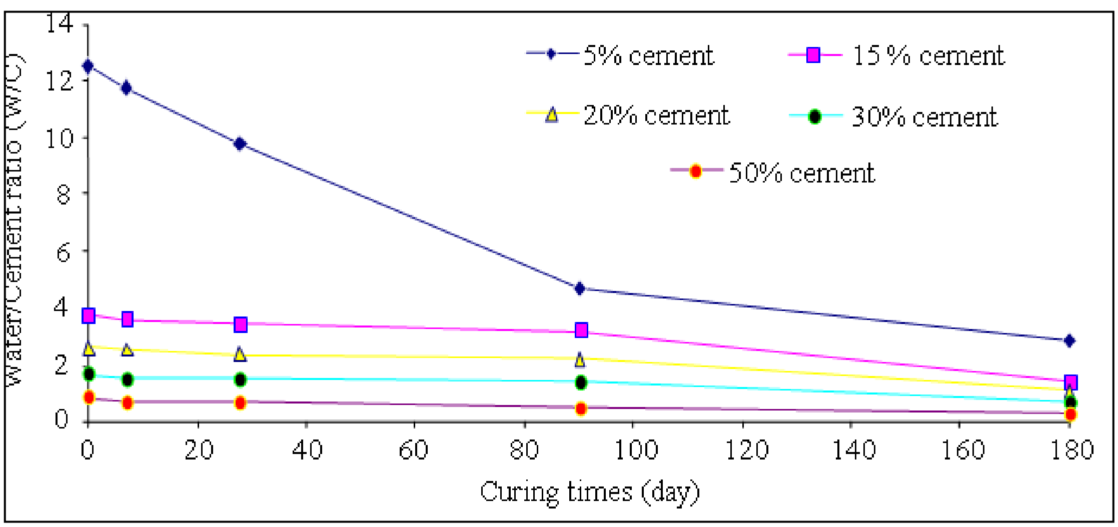


Figure 2.2:Air curing periods Vs water-cement ratio for stabilized peat soil samples containing differentamount of cement

2.4 Fiber Polypropylene and Cement as Stabilizer

Polypropylene fibers have been used to stabilizeclayey soil by researchersand it is reported that around0.4% of polypropylene fibers would provide the maximum strength when tested for unconfinedcompressive strength (Sivakumar, 2008).

Cement is increasingly used as astabilizing material for soil, particularly for the construction of highways and earthdams. It is due to the fact that cementhelps increase strength of soil given thecuring time (Das, 1999).

Polypropylene fibers are usually used in with cementto control cracks in hardened matrix (Duraisamy,Mullik, 2007).

According to Bell F.G (1993), any type of soil, except for of highly organic soils or some plastic clay, can be stabilized with cement and also any type of cement can be used for soil stabilization but ordinary Portland cement is most widely used. The addition of small amount of cement, that is, up to 2%, modifies the properties of a soil, while large quantities cause radical changes in these properties.

In addition, the advantages of fiber are:

i. Inhibits cracking due to plastic and drying shrinkage
ii. A cost effective alternative to wire mesh for crack control
iii. Reduces concrete permeability and improves durability
iv. Improves impact and abrasion resistance

Based on this characteristic and advantages, fibers are trusted to be the best choice to strengthen the peat soil.

Figure 2.3: Fiber polypropylene

Figure 2.4: Ordinary Portland Cement

According to Zhang et al. (2009), fibers can acted like bridge in order to prevent expending cracks caused by harmful pores and defects. Thus, it shows that randomly distributed fibers can be used to prevent crack in stabilized soil from stiffness and brittle behavior.

2.5 Unconfined Compressive Strength

Wong et al.(2008) have reported UCS of cement treated peat to be 142.5 kPa and the cement content was 187.5 kg/m^3 whereas, Hebib and Farrel (2003) have used 150 kg/m^3 cement and the UCS of peat reported was 210 kPa. Tang et al. (2007) have also reported an increase in UCS of soil upon treatment with cement and fibers.

According to Huat and Ali (2007), peat soil contain of significant organic material that form under a light surcharge load, and it is characterized with low shear strength, low compressibility and high water contain which required a standard laboratory test .Besides that, he discovers that, usually these laboratory tests including the in-situ tests identify parameters which areessential for foundation design.

Figure 2.5: Unconfined Compressive Strength Test

Based on the experimental data, he suggested that if these parameters indicate that the in-situ soil is not capable ofcarrying the design load then there are two alternatives to choose, either the limitation imposed bythe in-situ soil properties should be accepted, or use the following techniques enabling the loadsto lay on the site

i. Transfer the load to a more stable soil layer without improving the properties of the
in-situ soil.

ii. Improve in-situ soil properties with various techniques of ground improvement.

iii. Remove the soft soil and replace it, fully or partially, with better quality fill.

2.6 Strength mechanism

Eades and Grim, (1960), when soil-cement is compacted, chemical bonds develop between adjacent cement grain surfaces and between cement grain and soil particle interfaces. Not only does cement destroy the soil plasticity, it also increases the shear strength and reduces the water holding capacity of clayed soils.

It is shows that, as increased in cement contents, the strength of the soil sample also increased because cement act as binding component. In addition, cementation gel which produced from cements hydration and soil pore water will reduce calcium hydroxide. Calcium hydroxide will disassociate and raise the pH reading of the soil sample. The increasing in pH value of the peat will help in initial cement reaction and long term pozzolanic reaction.

Trembley et al. (2002), reported that the properties of cement treated organic soil depend not only on the content of the organic but also the nature or type of organic matter. The strength gained for cement stabilized peat will also depend upon the composition of the organic compound to organic acid due to the effect of biological influence.Apart from that, randomly distributed fibers will help in potential cracks upon loading caused by planes of weaknesses. Thus it will help in increasing the UCS strength of the soil sample.

CHAPTER 3

METHODOLOGY

3.1 Research Methodology

This research has been started with studying about problem related with peat soil. Then, it was continued to find the location of the peat soil. From the study, it was find out that the location of peat soil is at Teluk Intan and Hutan Melintang. Thus, the soil samples were collected from Hutan Melintang and bring back to the laboratory for testing. Figure 3.1 shows the project planning for this research. It starts with the study on peat soil structure and development. This study covers on peat soil characteristic such as the compressibility, shear strength and it stabilization. Next, the physical and chemical characteristic of the selected material which is cement and fiber polypropylene will be tested. Previous study was using different material such as cement mixed with silica or lime. For this project, fiber poly propylene and cement will be mixed together to analyze the stabilization of the peat soil. Then, Unconfined Compressive Strength (UCS) is being used to identify the compressive and shear strength of the peat after mix it with cement and fiber. All samples will go through curing process for 7 and 14 days before UCS test will be carried out. Finally, all the data and result will be collected and analyzed. Based on this result, we may know either the method used is effective and can be proposed for real life construction in order to reduce construction cost in peat soil area. This study consists of basic test on peat soil such as sieve analysis, Atterberg limit, organic content, optimum moisture content and specific gravity. For stabilization of peat soil, OPC and fiber was used as strength material and tested using UCS test and pH test for soil strength mechanism.

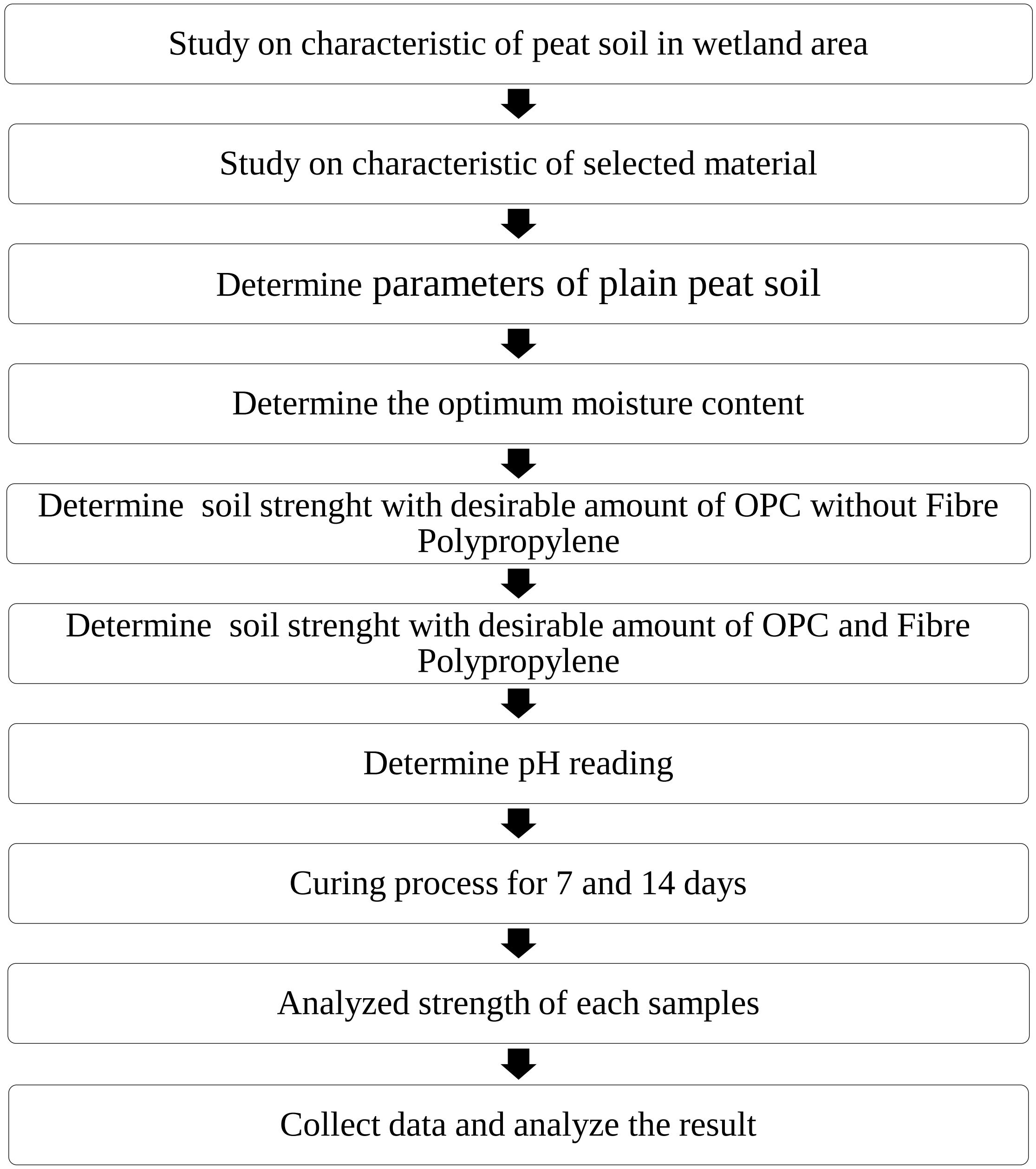


Figure 3.1: Project Planning

3.2 Preliminary Test

3.2.1 Sieve Analysis

This procedure is use to determine distribution of particle size of peat soil. Sieve analysis can be performed on any type of soil and granular material such as sands, crushed rock, clay, granite, grain and seed to minimum size depending on the method. This sieve analysis will use to determine the soil size distribution curve which passing through a stack of sieves of decreasing mesh opening sizes and by measuring the weight retained on each sieve. In construction, the suitability of a soil particular is dependent on the distribution of grain sizes in the soil mass. A stack of nine sieves is being selected for soil to be tested. The larger opening is placed at the top of the sieve followed by the smallest together with pan at the bottom. Fill up the soil which already dried for 24 hours in oven. Shake using sieve shaker for 10 minutes. After that, weight soil retained and passing in each sieve. Plot graph % passing vs sieve size.

Figure 3.2: Sieve Analysis

3.2.2 Atterberg limit

Changes on soil behavior usually use in estimating engineering properties of the soil by looking at the boundary of each state of the soil. This procedure determines Liquid Limit, Plastic Limit and Plastic Index. Liquid Limit is when the soil loses its ability to flow as a liquid and has a small value of shear strength. This is the stage where the soil just about to change from plastic state to the liquid state which minimum moisture content that causes the soil tends to flow as liquid. Plastic limit is when soil start to change to plastic behavior. From the test, it is shows that the soil achieved it plastic limit when it is rolled to 3mm diameter or when it starts to crumble. Figure 3.3 shows the changes of soil behaviors.

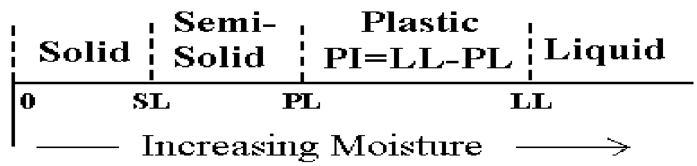


Figure 3.3: Changes stage of soil behavior

3.2.3 Optimum moisture content

In geotechnical work, design specification for compacted soil is important and will be analyzed using field test or in-situ test. These specifications normally are about water content and density required. Generally, strength, resistance and other engineering properties can be improved by increasing the soil density. The highest density resulted from specified compacted is optimum moisture content. Soil compacted at optimum moisture content will discreet soil structure that has a low strength. The process to determine optimum moisture content is started by sieving the soil to the size sieve required. After that, weight the compaction mould with it base and placed the moist soil with incremental of water in percent needed that mixed thoroughly into the soil.

The soil compacted with 3 layer and 27 blows for each layer from 300mm height above the soil. Weight the compacted soil with the mould again and take about 30g of the sample for determination of its moisture content. Repeat the procedure by adding some more percent of water until it give a total of at least five determinations. This optimum moisture content is being use for strength test for each material samples.

3.2.4 Organic Content

This test is important because organic content will influence properties of soil such as soil structure, soil compressibility and shear strength. Apart from that, it also affects the nutrient compositions, biological action, and water and air penetration rates. This experiment is carried out by placing the test specimen from moisture content test into muffle furnace at 440ºC for 24 hours. Then, take the reading and calculate the organic content.

3.3 Test to stabilized peat soil

3.3.1 Unconfined Compressive Strength

The unconfined compressive strength is a soil shear testing to measure shear strength. This test is performed by mixing the soil sample with soil strength material such as OPC and fiber polypropylene with optimum moisture content. After that, the soils are compacted with 3 layers at 27 blows for each layer in a mould using compactor machine. After compaction, sampling tubes are inserted into the soil to get the soil samples. Wrapped the samples and keep in air for 7 and 14 days for curing process. Once curing process is completed, performed UCS test. First, the initial diameter, length and mass of the sample are recorded. Then, soil sample is placed at the central of lower platen on the machine and ensure the specimen axis in vertical. Adjust the platen until top surface of the specimen contact with top platen.

Strain dial gauge are adjusted to zero. Switch on the UCS machine and take reading of strain applied to the sample at every 0.2mm strain dial reading until he sample failed. Removed the sample and moisture contents are measured. Lastly, stress-strain curve are plotted.

3.3.2 pH test

Addition of cement will raise the pH of the soil which in the turn increases the cation exchange capacity. Cation exchange processes result in the flocculation and cementation of soil particles. The rise in pH of the pore water increases the solubility and reactivity of silica and alumina (pozzolans) present in the soil particles (Bergado et al, 1996). Cement also provides free calcium that combines with pozzolans present in the soil to form more calcium silicate hydrates and calcium aluminate hydrates. This reaction is called pozzolanic reaction (Little, 1995). When adequate quantity of cement and water are added, the pH of the soil quickly increases to above 10.5, which enable the soil particles to break down. Silica and alumina are released and react with calcium from cement to form calcium-silicate-hydrate (CSH) and calcium-aluminate-hydrates (CAH). This compound forms the matrix that contributes to the strength of soil.

Figure 3.4: pH probe

3.4 Project activities

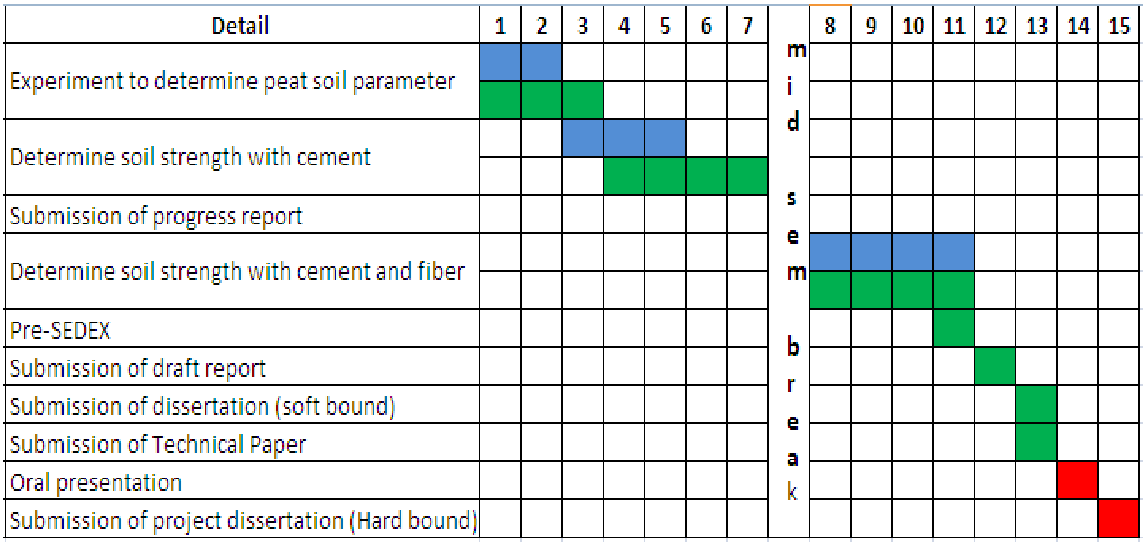


Figure 3.5: Gantt Chart for FYP 1

Legend

Done **Milestone**

Planning

Figure 3.5 shows the project for the semester II. Before conducting the experiments, all the safety laws must be obeyed to avoid any injuries during the experiment. The soil parameter and strength will be determined by using unconfined compressive strength (UCS) test with 7 and 14 days curing process to reach the objective of this project. This experiment will start with determination of peat soil properties and followed by strength test which various amount of OPC and fiber polypropylene will be added into the soil. Each sample will be cures for 7 and 14 days before being tested with UCS test to obtain it strength.

CHAPTER 4

RESULTS ANDDISCUSSIONS

4.1 Preliminary test

Properties	Values
Depth of sampling	5-50cm
Optimum moisture content	40%
Specific gravity	1.27
Liquid limit	144.3%
Organic content	82%
UCS for plain peat soil	9 kPa

Table 4.1: properties of the peat soil

Peat soil usually knows caused it contains high organic matter. For this experiment, peat soil was collected from HutanMelintang. Index properties tests on the peat soil have been conducted in order to determine the effectiveness of Ordinary Portland cement (OPC) and fiber polypropylene admixture in strengthening the peat soil. The tests include sieve analysis, optimum moisture content, liquid limit, organic content and specific gravity. Figure 4.1 shows the index properties of peat soil obtained from the tests. From the experiment, the organic content obtained is 82% which is proved that the sample collected is original peat soil. Normally, peat soil contains about more than 75% of organic content. The sample was taken in the depth of 5 to 50 cm form the ground. After that, the sample was bringing to the laboratory for the tests.

4.2 Optimum Moisture Content

Sample No.	**Moisture content (%)**	**Mass of mould + base + compacted soil**	**Mass of compacted soil only**	**ρ,(Mg/m^{3})**	**ρ_d ,(Mg/m^3)**
1	0	5.71	0.67	0.66	0.66
2	4	5.72	0.68	0.67	0.64
3	8	5.73	0.69	0.68	0.63
4	12	5.79	0.75	0.74	0.66
5	16	5.87	0.83	0.82	0.71
6	20	5.91	0.87	0.86	0.72
7	24	5.96	0.92	0.91	0.73
8	28	6.01	0.97	0.96	0.75
9	32	6.06	1.02	1.01	0.77
10	40	6.17	1.13	1.12	0.8
11	48	6.21	1.17	1.16	0.78
12	52	6.19	1.15	1.14	0.75
13	64	6.2	1.16	1.15	0.7
14	72	6.18	1.14	1.13	0.66
15	80	6.14	1.1	1.09	0.61

Table 4.2: Determination of dry density and Optimum moisture content

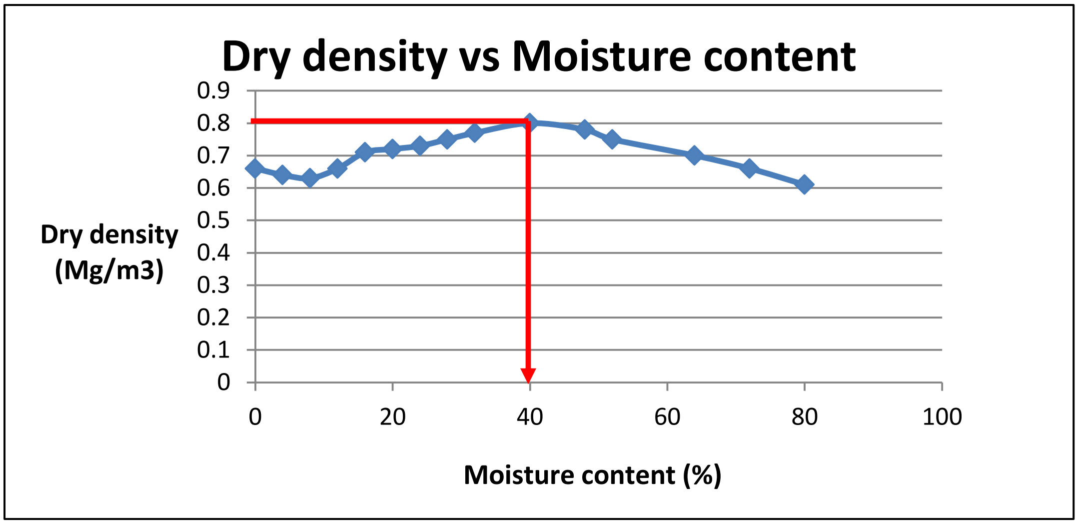


Figure 4.1: Graphic plot of the moisture-density relation

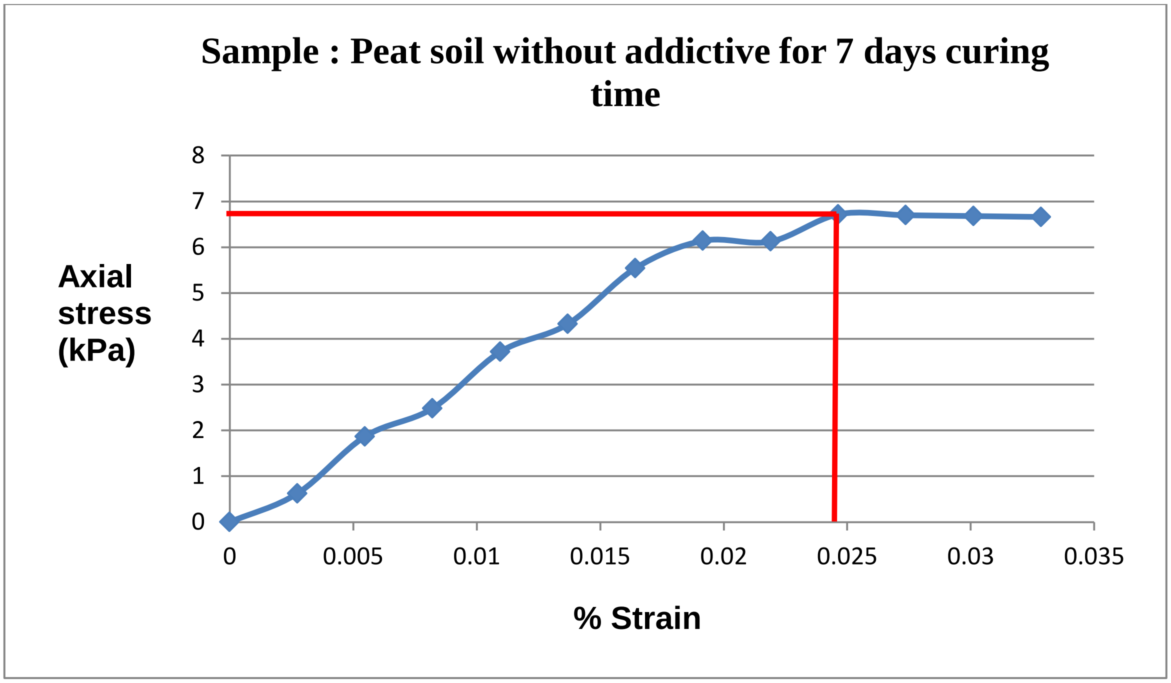
Table 4.2 shows the data obtained for optimum moisture content. This optimum moisture content is being used through out the experiment to analyzed peat soil strength. From the data, we can conclude that the optimum moisture content for peat soil is 40% as presented in Figure 4.1. The important of optimum moisture content is because it results in the greatest density for a specified compactive effort. If the sample was compacted at water content high than optimum moisture content, it will results in a relatively dispersed soil structure that is weaker, more ductile and softer. However, if the sample was compacted lower than optimum moisture content typically it will result in a flocculated structure that has opposite characteristics of soil compacted.

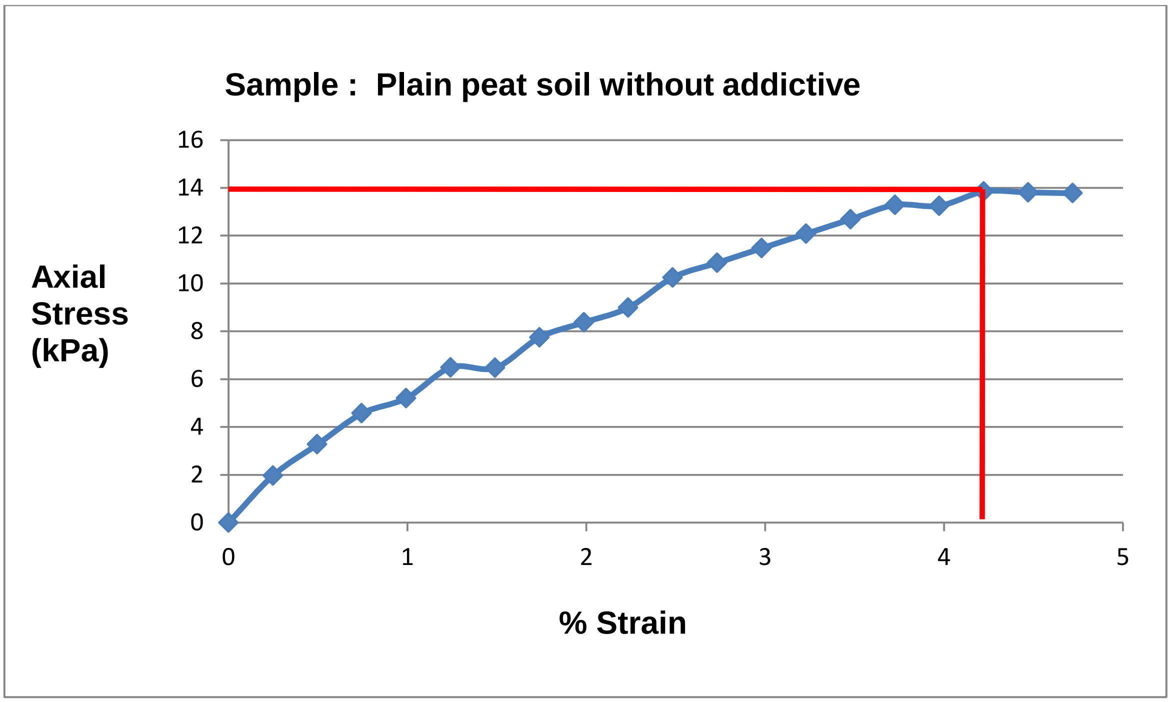
4.3 Curing Procedure

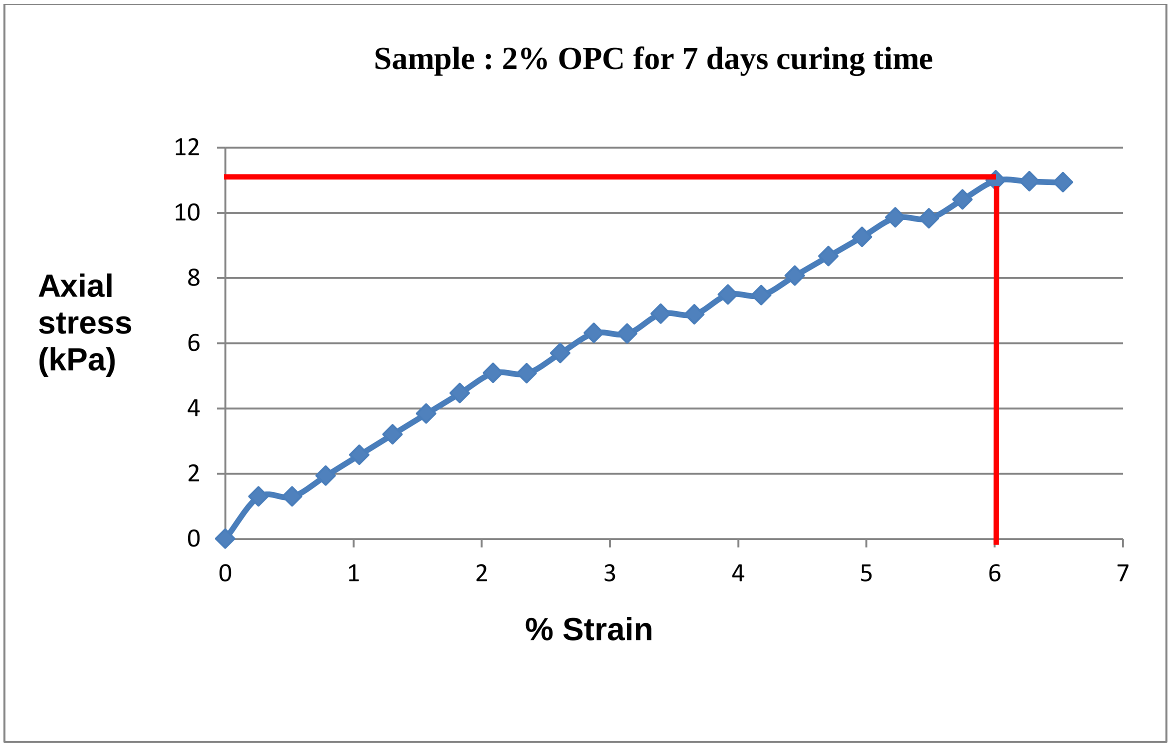
Air curing technique is being use to stabilized peat soil with OPC and fibers. During this curing period, peat soil samples were kept in normal temperature and out of water intrusion before tested with UCS test. From the experiment, the result shows in the Table 4.3 and figure 4.2 are the increasing in strength due to increase in curing period with different amount of OPC. For example, strength obtained for plain peat soil at 7 days curing period is 6.9 kPa increased at 14 days curing period to 14 kPa. Curing process will caused the moisture content of peat soil gradually loose and become drier and harder. Air curing technique is used to strengthen the stabilized peat soil samples by gradual moisture content reduction, instead of the usual water curing technique or water submergence method which has been a common practice of passed experiments for stabilized peat soil with cement described by Axelson et al. (2002), Duraisamy et al. (2006), and Fei et al. (2007).

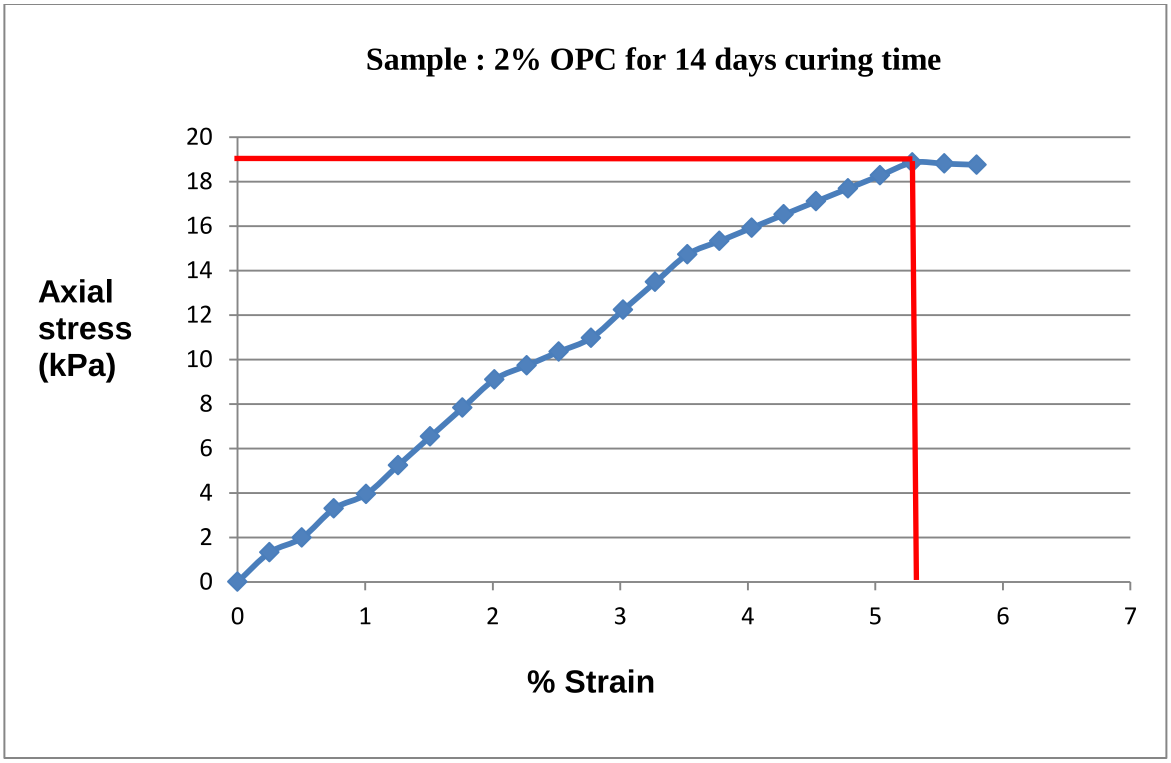
% Cement	**Strength Obtained (kPa)**	
	7 days curing period	**14 days curing period**
Plain	6.9	14
2%	11	19
5%	19	24
10%	39	49

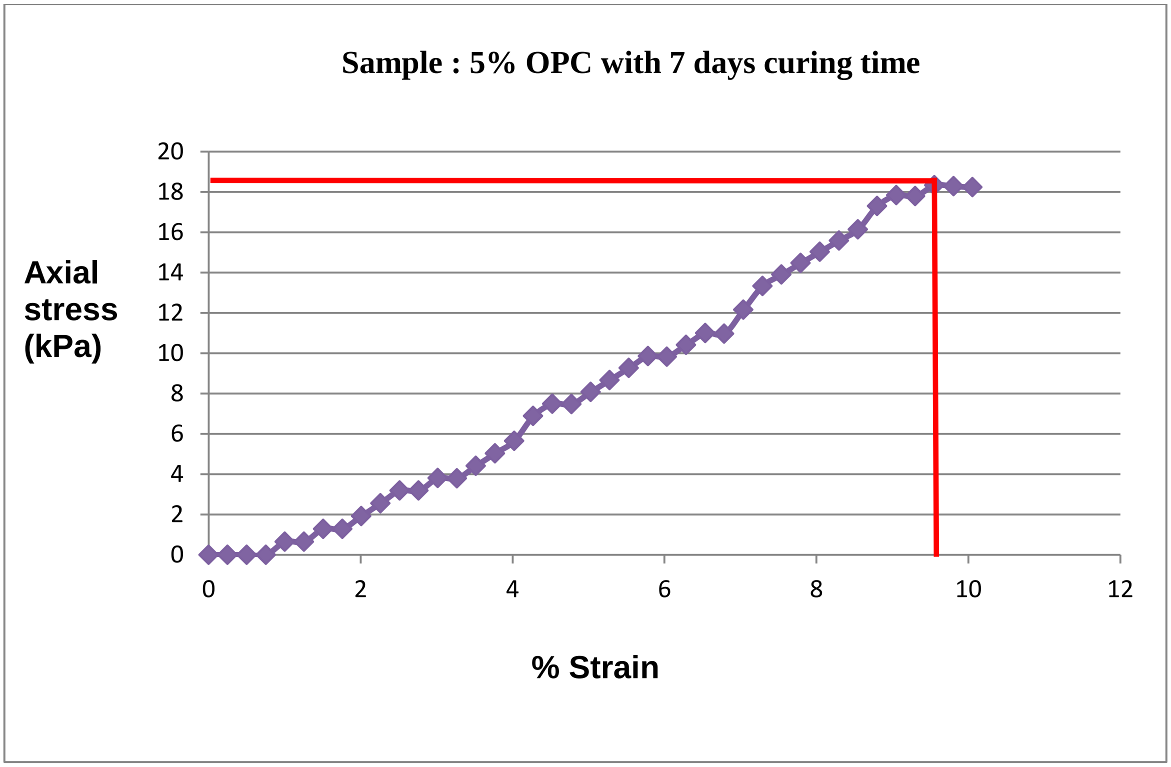
Table 4.3: Strength obtained for 7 and 14 days curing period for different amount of OPC


Sample : Peat soil without addictive for 7 days curing time
Axial stress (kPa)
8
7
6
5
4
3
2
1
0
0
0.005
0.01
0.015
0.02
0.025
0.03
0.035
% Strain

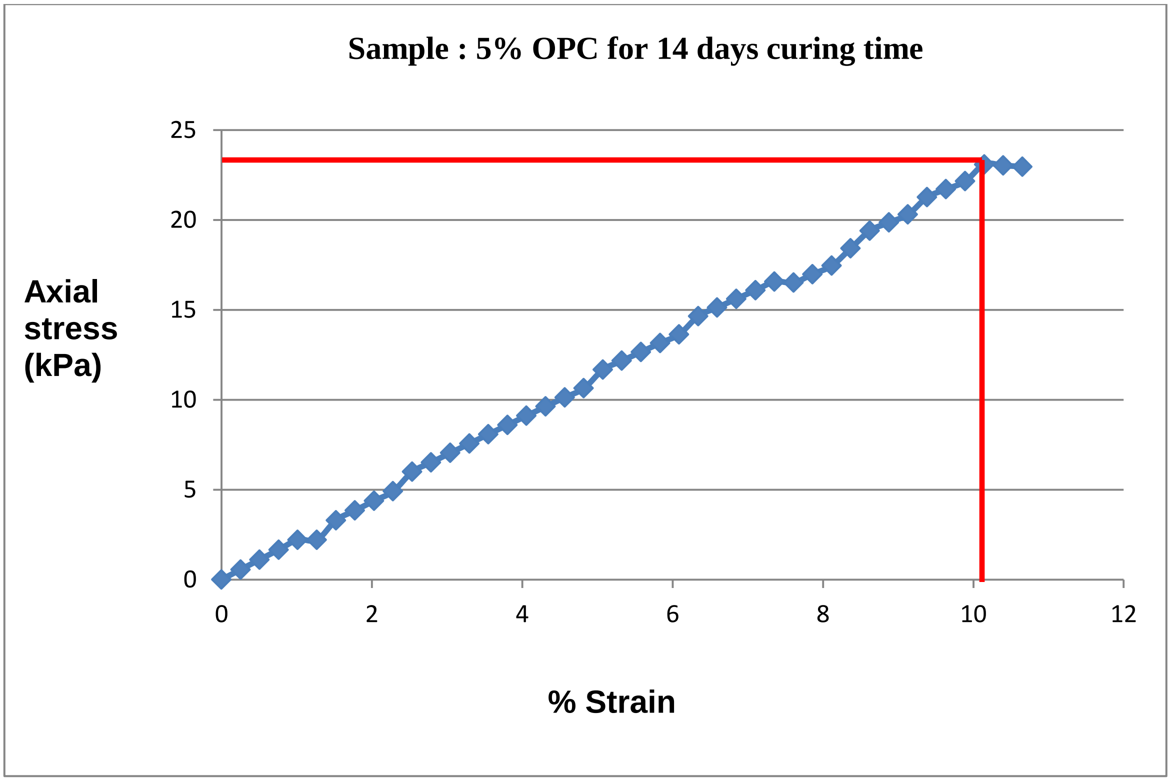

Sample : Plain peat soil without addictive
Axial Stress (kPa)
16
14
12
10
8
6
4
2
0
0
1
2
3
4
5
% Strain


Sample : 2% OPC for 7 days curing time
Axial stress (kPa)
12
10
8
6
4
2
0
0
1
2
3
4
5
6
7
% Strain

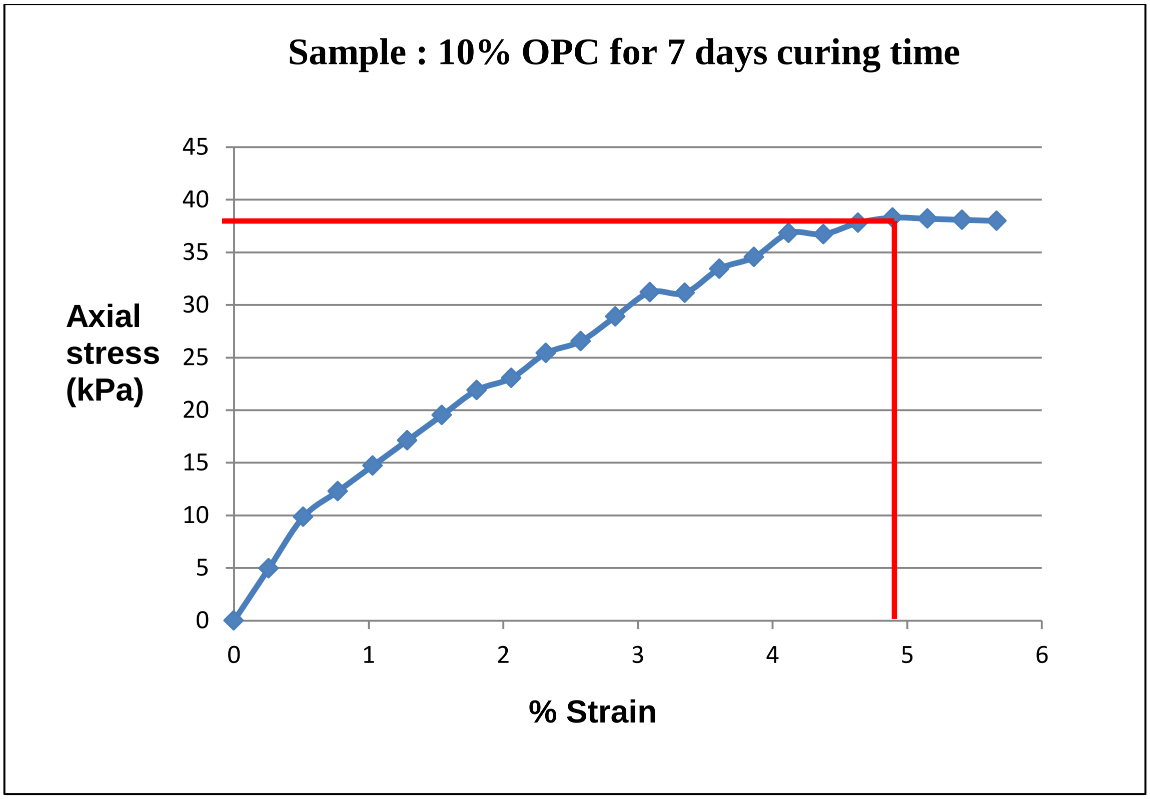

Sample : 2% OPC for 14 days curing time
Axial stress (kPa)
20
18
16
14
12
10
8
6
4
2
0
0
1
2
3
4
5
6
7
% Strain



Sample : 5% OPC with 7 days curing time
Axial stress (kPa)
20
18
16
14
12
10
8
6
4
2
0
0
2
4
6
8
10
12
% Strain



Sample : 5% OPC for 14 days curing time
Axial stress (kPa)
25
20
15
10
5
0
0
2
4
6
8
10
12
% Strain



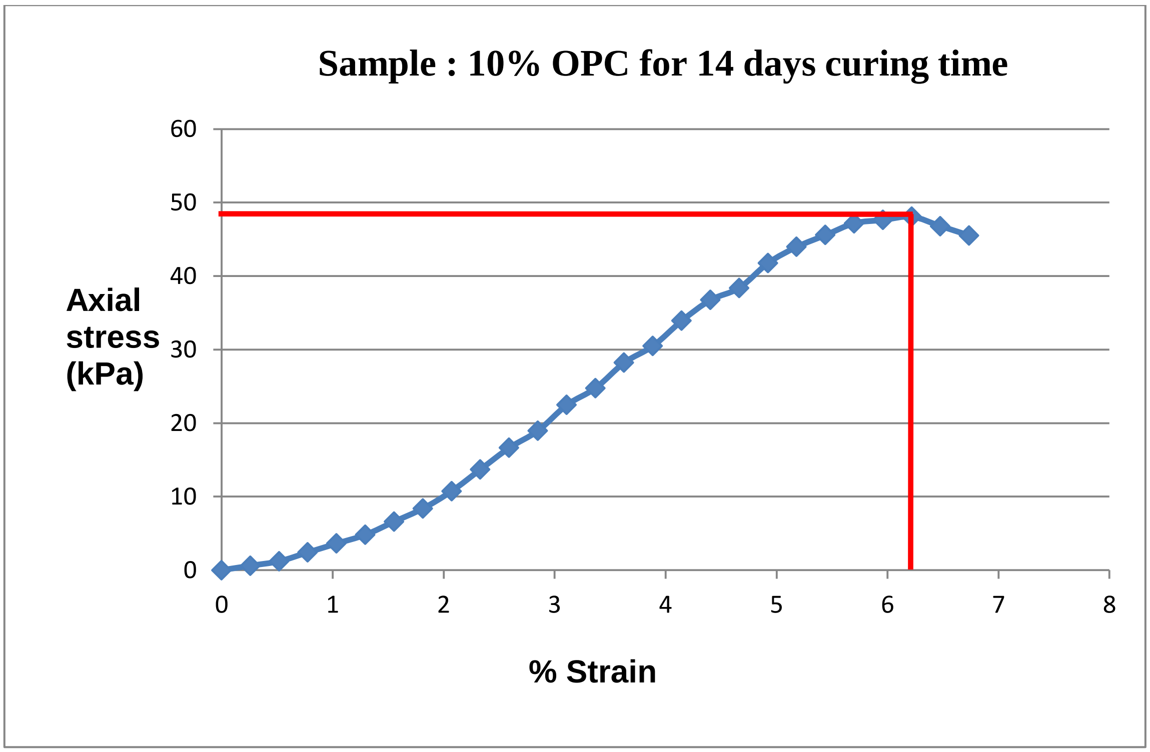


Figure 4.2: Increase in strength with different amount of OPC and curing time

4.4 Unconfined Compressive Strength

After determine the optimummoisture content, the plain sample without addictive and the mixture of 700g peat soil with 2%, 5% and 10% OPC were compacted in a UCS mould. The samples were compacted in 3 layers with 27 blows at each layer. Then, the sampling tube will be inserted into compacted soil to get the soil sample. The samples were cured for 7 and 14 days in normal temperature without water intrusion. After 7and 14 days, the strength of the samples are obtained using UCS test.For soil samples stabilized with various amount of OPC and 0.15% fiber polypropylene, the same method will be used.

From the test conducted in laboratory, the results obtained are as in table 4.4 below. The results in the table indicate that, the strength of the sample increase with increase in amount of OPC and curing time. In addition, polypropylene fibers also help in increasing of UCS value of the soil sample.In table 4.3, it is stated that UCS value obtained for 2% of OPC without fiber is 11 kPa for 7 days curing time and 19 kPa for 14 days curing time. However, for 2% of OPC with 0.15% fiber the strength of the soil increased to 16 kPa for 7 days curing time and 23 kPa for 14 days curing time.

Soil sample	**Strength Obtained (kPa)**	
	7 days curing time	**14 days curing time**
2% OPC + 0.15% Fiber	16	23
3% OPC + 0.15% Fiber	18	27
4% OPC + 0.15% Fiber	19	28
5% OPC + 0.15% Fiber	22	30
6% OPC + 0.15% Fiber	25	34
7% OPC + 0.15% Fiber	37	40
8% OPC + 0.15% Fiber	41	45
10% OPC + 0.15% Fiber	45	51

Table 4.4: Strength obtained for various amount of OPC with 0.15% fibers after curing period

According to the results shown on figure 4.3, the mixture consists of peat, OPC and addition of 0.15% fibers increased the UCS value of the sample. The strength of the soil sample obtained without fibers for 7 days curing time is 11 kPa for 2% OPC and 16 kPa for 2% of OPC with 0.15% fibers.

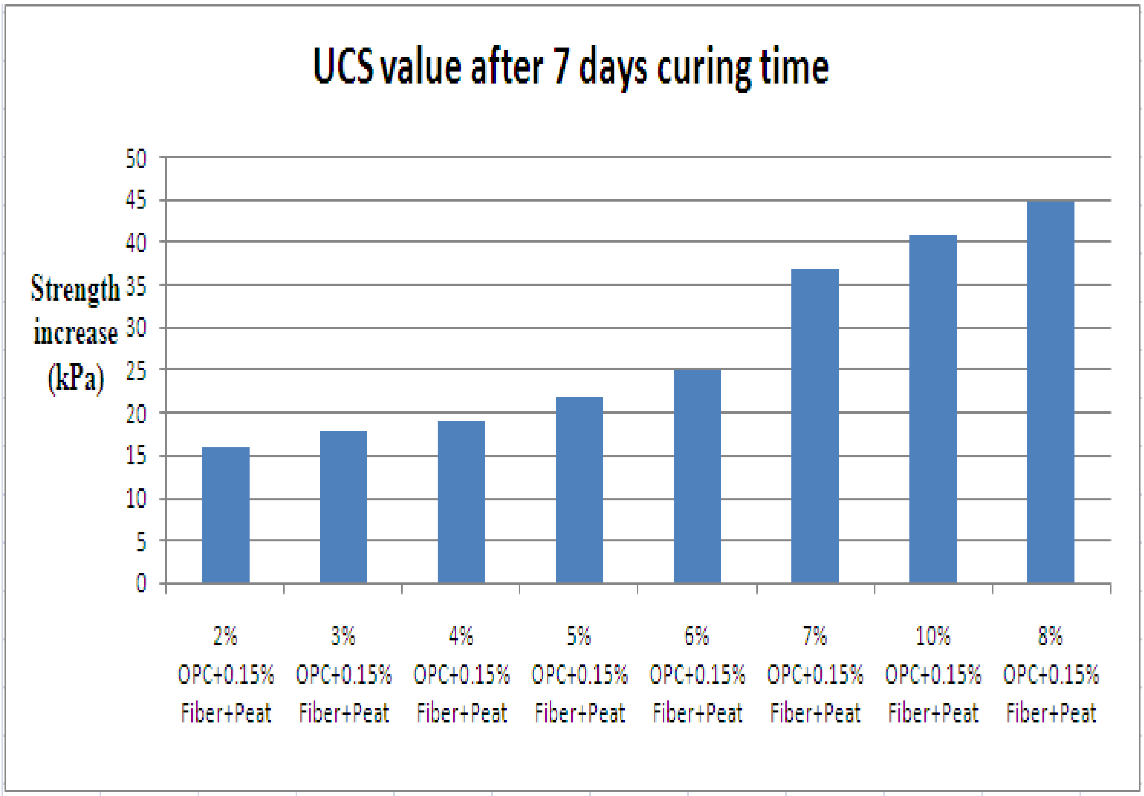


Figure 4.3: Different percentage of OPC with0.15% fiber vs strength increase after 7 days of curing

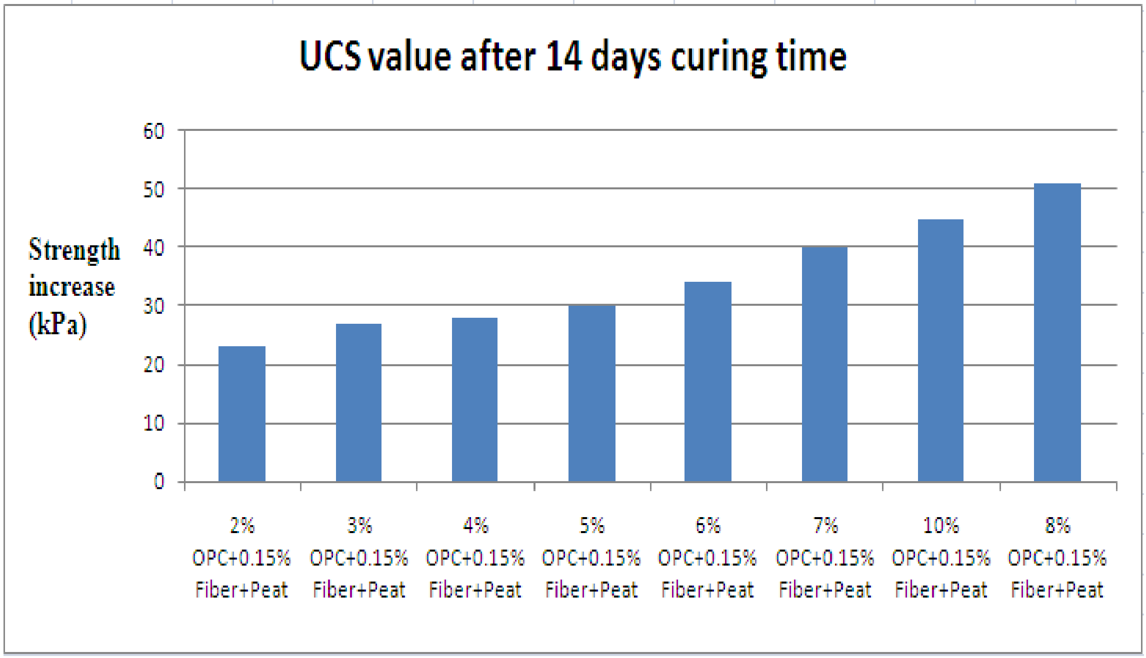


Figure 4.4: Different percentage of OPC with0.15% fiber vs strength increase after 14 days of curing

Result obtained from UCS tests shown on figure 4.4 indicates that, addition of 0.15% of fiber increase the UCS value of the samples. The increasing in curing time also leads to the increasing of the soil samples. For example, 2% of OPC with 0.15% of fiber for 7 days curing time is 16 kPa increased to 23 kPa after 14 days curing time.

The air curing technique as well as OPC and polypropylene fibers used for peat soil stabilization will increase the general rating of peat soil from very poor (CBR from 0 to 3%) to fair and good (CBR from 7 to above 20%), (Bowles,1978).

4.5 Strength mechanism

There are many factors that can affect peat soil stabilization. Normally, stabilization of peat soil depends on water content, physical, chemical and mineralogical properties, nature and amount of organic content and the pH of pore water. It is reported by Tremblay et al. (2002) that, the properties of cement treated organic soils depend not only on the content of the organic matter but also the nature or the type of the organic matter. Table 4.5 shows the pH reading increase due to increasing in OPC amount. Improvement in peat soil strength occurs when cation exchange and flocculation take place. Normally when clay present in peat and react with cement. Apart from that, cement hydration with pore water will decrease calcium hydroxide that will raise the pH of the soil and produce cementation gel. When cement contact with water, and replace dissimilar adsorbed cations on the colloidal surface it will produce free calcium cations (Ca^{2+}). It is reported that high concentration of Ca^{2+} and OH^{-} ions is created in the cement-soil matrix immediately after addition of water to the cement (Duraisamy et al., 2006).

Cement content (%)	**pH reading**			
	1	**2**	**3**	**Average**
Plain	3.57	3.41	3.38	3.45
2	4.66	4.66	4.66	4.66
5	5.92	5.94	5.91	5.92
10	8.10	8.02	8.10	8.07

Table 4.5: pH reading based on cement content

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The final goal of this study is to determine the effectiveness of ordinary Portland cement (OPC) and fiber polypropylene either it can be use in strengthening of peat soil. To achieve the objective, a few task and research need to be carried out by studying the index properties of peat soil, affect in percent increase of ordinary Portland cement and fiber polypropylene in term of strength.

For this study, various amounts of OPC and fibers are used in order to increase the strength of peat soil. The amount use is 2%, 5% and 10% for OPC without fiber polypropylene. For stabilization of peat soil with OPC and fiber polypropylene, the amount of OPC used are 2%, 3%, 4%, 5%, 6%, 7%, 8% and 10% with 0.15% of fibers. Air curing technique was used for curing procedure where the sample is keep in air and out of water intrusions during the curing period. The strength of the samples is analyzed by using unconfined compression strength (UCS) after 7 and 14 days curing process.

Comparison has been made for the experiments at various amounts of OPC together with fibers and curing time with plain peat soil without any addictive in order to see the differences of the soil strength. Results obtain indicate that, curing periods caused the samples loose some of the moisture content. Thus, as the samples lost water, its water cement ratios being decreased and UCS values increased. The result has been analyze and formed into table and graph. From the graph of UCS test, it shows that strength of plain peat soil is increase compared to soil with some amount of OPC. Thus, as conclusion we can say that OPC and fiber polypropylene can be used as strengthen mechanism to peat soil.

5.2 RECOMMENDATION

There are many peat soil areas found in Malaysia and given many problems in construction activities because of its characteristics which are loose, unconsolidated surface deposit and low bearing capacity. Thus, it becomes imperative to improve its engineering behavior. For this study, ordinary Portland cement and fiber polypropylene has been used for soil stabilization. For future research, other material can be carried out to further improve the friction and bonding mechanism in the peat. Present research was using fibrous peat. For further research, different types of peat such as hemic and sapric can be carried out since the quantity of binders required will depend on particle size of the peat. Thus, future study can be done for other types of peat.

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