PEAT SOIL STABILIZATION USING MAGNESIUM CHLORIDE

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Dedication to My Beloved Parents, Family and Friends

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ABSTRACT

Peat soil is a one of the worse soil to be used as subgrade layer and very problematic due to high moisture content, high void ratio and high compressibility. Peat soils are found in large quantities in Malaysia especially in Sarawak. The peat soil is very important because this soil much weaker and more compressible than inorganic (mineral) soils. This paper will present the effect of peat soil with chemical stabilizer in terms of compressive strength. The chemical that used for this study is Magnesium Chloride ($MgCl_2$) with the percent content of the stabilizer is 3%, 6%, 9%, 12% and 15% by weight of soil sample. For this research, the peat soil taken from Ulu Sikat, Mukah, Sarawak. Atterberg Limit Test is carried out to obtain the liquid limit and plastic limit value. Standard proctor test are used to determine the Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) for untreated soil. The value of OMC & MDD that determine from the compaction test were used to prepared sample for Unconfined Compressive Strength (UCS). The samples were cured at 3, 7 and 28 days and UCS was carried out to determine the compressive strength of soil samples at optimum moisture content. From this research, it observed that the strength of soil mixed with $MgCl_2$ increase with the time. The highest value of compressive strength that obtained from this study is 96 kPa which is peat soil mixed with 6% $MgCl_2$ at 28 days curing time. Peat soil mixed with 6% content $MgCl_2$ was chosen as the optimum value that was added to the peat soil for microstructure analysis.

ABSTRAK

Tanah gambut adalah salah satu tanah yang teruk untuk digunakan sebagai lapisan subgred dan sangat bermasalah kerana kandungan air yang tinggi, nisbah lompang tinggi dan kebolehmampatan yang tinggi. Tanah gambut didapati dalam kuantiti yang besar di Malaysia terutama di Sarawak. Tanah gambut adalah sangat penting kerana tanah ini lebih lemah dan lebih mampat daripada tanah bukan organik (mineral). Kertas kerja ini akan membentangkan kesan tanah gambut dengan penstabil kimia dari segi kekuatan mampatan. Bahan kimia yang digunakan untuk kajian ini adalah Magnesium Klorida ($MgCl_2$) dengan kandungan peratus daripada penstabil ialah 3%, 6%, 9%, 12% dan 15% mengikut berat sampel tanah. Untuk kajian ini, tanah gambut diambil dari Ulu Sikat, Mukah, Sarawak. Ujian 'Atterberg Limit' dijalankan untuk mendapatkan nilai 'Liquid Limit' dan 'Plastic Limit'. Ujian 'Standard Proctor' digunakan untuk menentukan Kandungan Lembapan Optimum (OMC) dan Ketumpatan kering maksimum (MDD) untuk tanah yang tidak dirawat. Nilai OMC & MDD yang ditentukan daripada ujian pemadatan digunakan untuk menyediakan sampel Ujian 'Unconfined Compressive Strength' (UCS). Sampel yang di rawat pada 3, 7 dan 28 hari untuk Ujian UCS telah dijalankan untuk menentukan kekuatan mampatan sampel tanah pada kandungan kelembapan optimum. Dari kajian ini, ia diperhatikan bahawa kekuatan tanah yang telah dicampur meningkat dengan peningkatan $MgCl_2$ dengan masa berbanding sebelum dicampur oleh $MgCl_2$. Nilai tertinggi kekuatan mampatan yang diperolehi daripada kajian ini ialah 96 kPa iaitu tanah gambut dicampur dengan 6% $MgCl_2$ pada hari ke-28. Tanah gambut dicampur dengan kandungan 6% $MgCl_2$ dipilih sebagai nilai kekuatan optimum tanah gambut untuk menganalisis mikrostruktur pada tanah yang sebelum dan selepas didirawat.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

w	-	Moisture Content or
γ_d	-	Unit weight of dry soil
γ_w	-	Unit weight of water
SG	-	Specific Gravity
kPa	-	Kilo Pascal
µm	-	Micro meter
$MgCl_2$	-	Magnesium Chloride
OMC	-	Optimum Moisture Content
MDD	-	Maximum Dry Density
UCS	-	Unconfined Compressive Strength
JPS	-	Jabatan Pengairan & Saliran
AASTHO	-	American Association of State Highway and Transportation Officials
ASTM	-	American Society for Testing & Material
BS	-	British Standard
PL	-	Plastic Limit
LL	-	Liquid Limit
PI	-	Plasticity Index
DDL	-	Double Diffuse Layer
SEM	-	Scanning Electron Microscopy
EDAX	-	Energy Dispersive Analysis by X-Rays
UTM	-	Universiti Teknologi Malaysia
UTHM	-	Univesiti Tun Hussein Onn Malaysia

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background Study

In engineering construction, the problems with soil always occur even during construction or after construction. This happen as the soil cannot reach the required specification such as the bearing capacity of soil is too weak to support superstructure above it. The existing soil at a construction site are not always be totally suitable for supporting structures such as buildings, bridges, highways, and dams. Hence, if the building is constructed on the poor soil, many problems will occur after the construction finished. The building will be cracked because of the settlement of the soil.

There are many types of soil that have different of composition such as gravel, sand, silt and clay. Soils also contain organic matter that generally formed below high water table like in swamps and wetlands area where the rates of decomposition of plant remain slow. These soils are called as ‘organic soils’ if their organic content exceeds 20% of their dry mass and if exceeds 75% and more, it called as ‘peat’.

Peat soils are found largely in Malaysia and about 2.7 million hectares of peat swamps or accounting 8% of the country's total land area. Johor and Sarawak are found to have the widest coverage of peat and Sarawak has the largest area of peat-land in the country, covering approximately 1.7 million hectares. Peat soils are the worse soils and due to development of infrastructure and this soil cannot be avoided anymore.

According to Huat et. al. (2014), any material that contains carbon is called 'organic'. The identification of organic soils is very important because they are much weaker and more compressible than inorganic (mineral) soils. This soil normally has a dark brown colour, a spongy consistency and an organic odour.

Due to sensitivity on peat soil for settlement, low shear strength and high moisture content the special soil-improvement techniques are required to overcome such soil problem. There are many types of soil improvement such as consolidation of soil, stabilization soil and soil densification. The consolidation of soil is a process the removal of water from soil. In other words, it is the squeezing out of water from the soil to make it denser (Nadgouda, 2006).

The purpose of soil densification technique is to increase the unit weight and thus the shear strength. The granular soil deposits the in situ soil usually very loose and could present a large elastic settlement for site construction and to prevent this, the soil densification should apply for this problem to decrease the void ratio between the particles.

The stabilization of soil is important to be applied in the construction. The main purposes of soil stabilization are to improve soil strength and increase resistance to softening by water through bonding the soil particles, water proofing the particles or combination of two (Sherwood, 1993; Makusa, 2012). Besides, soil stabilization also can be defined as the modification of the characteristics of soil in

order to enhance the engineering performance of the soil, for example improve the density of soil, mixing the soil with additives to change the chemical and physical properties such as stiffness, compressibility, permeability, workability, lower the ground water level and eliminate weak soil.

Soil stabilization can be accomplished by two methods which is mechanical stabilization and chemical stabilization. Mechanical stabilization can be achieved through physical process by altering the physical nature of native soil particles by either induced vibration or compaction or by incorporating other physical properties such as barrier or nailing. Besides, the chemical stabilization depends on the chemical reaction between stabilizer (cementations material) and soil minerals (pozzolanic materials) to achieve the desired effect (Makusa, 2012).

1.2 Problem Statement

Peat soil can be present as a material of soft soils and can be classified as highly organic. Generally peat is mainly composed by fibrous organic material which is decomposition of process of plants such as leaves. Normally peat soil has a dark brown and black colour, a spongy consistency and an organic odour. There are special characteristics and consideration for construction on these soils. Peat soil has a high natural moisture content (up to 500%), high compressibility, including significant secondary and tertiary compression but low in shear strength usually in 5 to 20 kPa. Besides, it also high permeability compared with clay and high in degree of special variability (Huat et. al, 2014).

Peat soil is a very problematic soil until soil scientist and engineers mentioned this soil is best to avoided as far as possible for any construction. This soil also subjected to instabilities such as localized sinking and slip failure and to massive

primary and long term secondary and even tertiary settlements when load are increase. This site is difficult to be access to the sitesed due to discomfort of unstable platform (Huat et. al., 2014).

According to Huat et. al. (2014), for development on this soil such as infrastructure work, basic civil engineering structures are required. It is including for irrigation and drainage, water supply, roads and farm building. In roadwork, usually peat soil will be used as a subgrade layer which is the lowest layer in cross section of road and it is very important layer and need to give more attention. During construction of the roadwork, this subgrade layer can be delay the whole construction work due to difficulty to stable it or need to be replace by others filling material.

As an engineer, they need to develop safer and cheaper engineering design and construction technique. In the past, road in swampy peat soil can be disappear one night due to lack of construction technique or less attention is given for this type of soil. Therefore, the soil should be treated. Soil stabilization is among a popular method used to improve the engineering of the soil.

1.3 Objectives of Study

The aim of this study is to investigate the strength characteristic and microstructure study of peat soil stabilized with Magnesium Chloride. By carry out this study, the following objectives will be achieved:

1. To determine the properties of peat soil.

2. To compare the effectiveness of strength between treated and untreated peat soil.

3. To study the microstructural behaviour of peat soils treated with Magnesium Chloride.

1.4 Scope of Study

For this study, peat soil and chemical stabilizer are used. The sample of peat soil is taken as a disturbed sample and Magnesium Chloride are used as a chemical stabilizer.

The term of soil that has been used in this study purposely to describe that the soil is highly organic and high in compressibility. Soil samples are taken from project of Coal Mining (extraction & transportation of coal) and Rehabilitation of mined out area at BC2 Ulu Sikat, Mukah Sarawak. The soils in this area are considered as a swampy peat soil which is having high moisture content and highly organic.

The chemical stabilizer has been used is Magnesium Chloride ($MgCl_2$). The $MgCl_2$ are obtain based on previous journal on clay with Magnesium Chloride (Turkoz et. al). The $MgCl_2$ is crystal physical form and need to be dissolved with water to become liquid condition. The chemical content that used for this study is 3%, 6%, 9%, 12% and 15% based on the soil weight.

The soil sample has been taken at 0.5m depth from the ground surface. The sample was taken at a large area and the soil volumes are determined by the numbers of sample that prepared. The sample was kept in the container and brought to Universiti Teknologi Malaysia (UTM).

The sample was sent to the geotechnical laboratory to be examined and tested. The engineering properties of soil samples such as classification of soil, the compressive strength of soil samples between treated and untreated was determined. The Atterberg Limit test is carried out to determine the soil characteristics such as Plastic Limit, Liquid Limit and Plasticity Index. Loss of Ignition test was obtained the organic content of peat soil.

In order to determine the compaction and strength of soil, the two testing has been conducted. The standard proctor test has been done to get the optimum moisture content (OMC) and maximum dry density (MDD) of the soil.

By determined the OMC and MDD from the compaction test, cylindrical soil specimens of 38 mm in diameter by 76 mm height is prepared for Unconfined Compressive Strength (UCS). For this testing, five samples are prepared with different ratio of $MgCl_2$. The UCS tests are performed based on of 3, 7, and 28 days curing period.

1.5 Significant of Study

In engineering construction, many methods are applied to increase the strength of peat soil. Soil stabilization with additive such as cement, lime, fly ash or combination of this is among a popular method used to improve the strength of peat soil. The application of this method has recently been further expanded. The more common uses today are for stream bank protection, grade control (drop) structures, and pond liners.

In Malaysia, most of the peat soil have extremely high moisture content, higher compressibility and low shear strength. Peat soil faced many problems in construction area even at road construction and building construction. Settlement will be occurred at the ground if the soil is not treated properly. The ground improvement is a very important and as a key basic in the engineering construction and very economic method.

Treatment of peat soils with Magnesium Chloride has potential to improve the geotechnical properties of problematic soils. Nowadays, Magnesium Chloride commonly used for anti-icing agents on roads than as a soil stabilizer for the country experienced a winter season. The materials also used to control dust and humidity on roads and reduce the scattering of coarse particles from the surfaces.

Magnesium Chloride is easy to be found and produced. This material can be extracted from brine or sea water and generally called as a salt. Salt will not harm to us if we touch it and wisely use in our food and as a nutritional supplement.

Besides, the addition of salts also will modify the physico-chemical characteristics of soil and reduce the adsorption capacity or reducing the phenomenon on swelling (Belabbaci et. al, 2013).

REFERENCES

Ates, A. (2013). *The Effect of Polymer-Cement Stablization on the Unconfined Compressive Strength of Liquefiable Soils*. Hindawi Publishing Corporation , Article ID 356214.

Belabbaci, Z., AissaMamoune, S.D., and Bekkouche, A. (2013). Laboratory Study of the Influence of Mineral Salts on Swelling (KCI, $MgCl_2$). *Earth Science Research,* Vol. 2, No.2.

British Standard Institution (1990a). *Bristish Standard Method of the test for soils for civil engineering purposes: Part 2, Classification test*. London, BS1377.

British Standard Institution (1990a). *Bristish Standard Method of the test for soils for civil engineering purposes: Part 3, Chemical and electron-chemical test.* London, BS1377.

British Standard Institution (1990a). *Bristish Standard Method of the test for soils for civil engineering purposes: Part 4, Compaction-related tests.* London, BS1377.

British Standard Institution (1990a). *Bristish Standard Method of the test for soils for civil engineering purposes: Part 7, Shear stength tests (total stress).* London, BS1377.

Budhu, M. (2000). *Sil Mechanics & Foundations.* United States of America: John Wiley & Sons, INC.

Construction Research Istitute of Malaysia (CREAM) (2014). Seminar Construcion On Peat Soil in Malaysia. 6 May 2014, Sarawak.

Das, B. M. (2007). *Principles of Geotechnical Engineering.* Canada: Nelson.

Deboucha, S., Hashim, R. and Alwi, A. (2008). Engineering Properties of Stabilized Tropical Peat Soils. *EJGE,* Vol. 13, Bund.E.

Dehghanbadanadaki, A., Ahmad, K., and Ali, N. (2013). Geotechnical Characteristics of Potian Peat. *Caspian Journal of Applied Sciences Research*, 2(11),16-25.

Duraisamy, Y. (2009). *Soil Mechanics Laboratory Manual.* Pahang: Universiti Malaysia Pahang.

Evett, C. L. (2004). *Soils and Foundations.* USA: Pearson Prentice Hall.

Hashim, R., and Md, S.I. (2008). Properties of Stabilized Peat by Soil-Cement Column Method. *EJGE,* Vol. 13, Bund.J.

Huat, B.B.K., Prasad, A., Asadi, A & Kazemian, S. (2014). *Geotechnics of Organics Soils and Peat.* London, UK: Taylor & Francais Group.

JPS. (2001). *Water Management Guidelines for Agricultural Development in Lowland Peat Swamps of Sarawak.* Sarawak.

Kolay, P.K., Aminur, M.R., Taib, S.N.L., and Mohd Zain, M.I.S. (2011). Stabilization of Tropical Peat Soil from Sarawak with Different Stabilizing Agents. *Geotech Geocl Eng*, 29:1135-1141.

Latifi, N., Eisazedah, A., and Marto, A. (2013). Strength behaviour and microsturctural characteristics of tropical laterite soil treated with sodium silicate-based liquid stabilizer. *Environment Earth Sciences*, 1-8.

Newman, K. and Tingle J.S. (2004). Emulsion Polymers for Soil Stabilization. *2004 FAA Worldwode Airport Technology Transfer Conference*, Atlantic City, New Jersey, USA.

Nadgouda, K. (2006, November 20). *Consolidation of soil*. Retrieved July 1, 2014, from Geotechnical Engineering 101.

Moayedi, H., Kazemian, S., and Huat, B.B.K. (2013). Shear Strength Parameter of Improved Peat by Chemical Stabilizer. *Geotech Geocl Eng,* 31:1089-1106.

Rashid, A.S.A., Kalatehjari, R., Noor, N.M., Yaacob, H., Moayedi, H., and Lim, K.S. (2014). Relationship between liquidity index and stabilized strength of local subgrade material in a tropical area. *Measurement 55,* 231-237.

Said, J.M., and Taib, S.N.L. (2009). Peat Stabilization with Carbide Lime. *UNIMAS E-Journal of Civil Engineering,* Vol 1: Issues 1.

Sha'abani, M., and Kalantari, B. (2012). Mass Stabilization Technique for Peat Soil. *ARPN Journal of Science and technology*, 512-526.

Tan, C.K. (2010). *Microstructure and Mineralogical Study of Organic Soils*. Master Project Report. Universiti Teknologi Malaysia, Faculty of Civil Engineering.

Turkoz, M., Savas, H., Acaz, A., and Tosun, H. (2014). The effect Magnesium Chloride solution on the engineering properties of clay soil with expensive and dispersive characteristic. *Applied Clay Science*, 1-9.

Wong, L.S., Hashim, R., Ali, F., (2012), Utilization of sodium bentonite to maximize the filler and pozzolonic effects of stabilized peat. Engering Geology 152 56-66.