CHEMICAL STABILIZATION OF AMORPHOUS PEAT VIA CEMENT AND FLY ASH WITH LIME

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NYEMAS DEWI PRAMITA BINTI AIE

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To my beloved parents and everyone who involved directly or indirectly in this journey.

Thank you.

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Abstract

Organic soil such as peat is a very problematic soil and poor in strength. However previous researches have proved that the compressive strength of peat can be improved by using various method of soil improvement including chemical stabilization method. Due to that, the aim of this study is to improve the compressive strength of amorphous peat, various water to additive ratio were used to obtain the optimum Unconfined Compressive Strength (UCS) value. In this study, peat samples were collected in Jalan Kampung Meranek, Samarahan and mixed at its natural moisture contents with cement and fly ash plus lime at different water additive ratios of 3.0 and 3.5. The compressive strength of the sample was obtained by Unconfined Compressive Strength Test (UCS) and analyzed.

Abstrak

Tanah organik seperti tanah gambut merupakan tanah yang sangat bermasalah dan mempunyai kekuatan yang rendah. Walau bagaimanapun penyelidikan terdahulu telah membuktikan bahawa kekuatan mapat tanah gambut dapat ditingkatkan dengan menggunakan pelbagai kaedah membaik pulih tanah termasuklah kaedah penstabilan kimia. Oleh itu, mencari bahan kimia yang lebih sesuai adalah sangat penting berbanding tahun – tahun lalu dengan menyiasat pelbagai nisbah bahan tambahan dan menganalisa keputusannya. Disebabkan itu, tujuan kajian ini dijalankan adalah untuk meningkat kan kekuatan mampat tanah amorfus dengan menggunakan penstabil kimia yang palin efisien lagi ekonomi. Dalam kajian ini tanah gambut di ambil dari Jalan Kampung Meranek, Samarahan dan digaul dengan kandungan lembapan semulajadi bersama simen dan bersama abu terbang bersama dengan kapur pada nisbah bahan tambahan air 3.0 dan 3.5. Kekuatan mampat sampel diperolehi daripada ujian mampatan tak terkurung (UCS).

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LIST OF SYMBOLS

Ha	-	Hectares
m	-	Metre
km	-	Kilometre
Pt	-	Peat
PtO	-	Peaty organic soils
O	-	Organic soils
CaO	-	Calcium Oxide
SiO_2	-	Silicon dioxide
Al_2O^3	-	Alumina
Fe_2O_3	-	Iron oxide
MgO	-	Magnesium oxide
SO_3	-	Sulphur Trioxide
Na_2O	-	Sodium Oxide
K_2O	-	Potassium Oxide
$CaSO_4$	-	Calcium sulphate
kPa	-	Kilopascal
kN	-	Kilonewton
TiO_2	-	Titanium oxide
P_2O_5	-	Phosphorus
MnO	-	Manganese (II) oxide
Ca	-	Calcium
°	-	Degree
C	-	Celcius
Kg/m^3	-	Kilogram per cubic metre
mbar	-	milibar
µm	-	Micrometre
Mm	-	Millimetre
Hrs	-	Hours

LIST OF ABBREVIATIONS

DSM	-	Deep Soil Mixing
UCS	-	Unconfined Compressive Strength
CREAM	-	Construction Research Institute of Malaysia
FA	-	Fly Ash
ASTM	-	American Standard for Testing and Materials
QL	-	Quick lime
OPC	-	Ordinary Portland Cement
CBR	-	California Bearing Ratio
W/A	-	Water to additive
W/C	-	Water to cement
LOI	-	Loss on ignition
CMS	-	Cahaya Mata Sarawak
BS	-	British Standard

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

The construction industry plays a major role in the economic growth, development and economic activities. It is known that human population is increasing every day all around the world. Rapid industrial and commercial expansions in recent years have created the need for more land. However, not all areas in the world are covered with good soil that have strong properties and can sustain loads from buildings and roads. Some of the areas in the world are covered with soft soils that are not suitable for construction and development. This soft soils refer to peat or also known as organic soils.

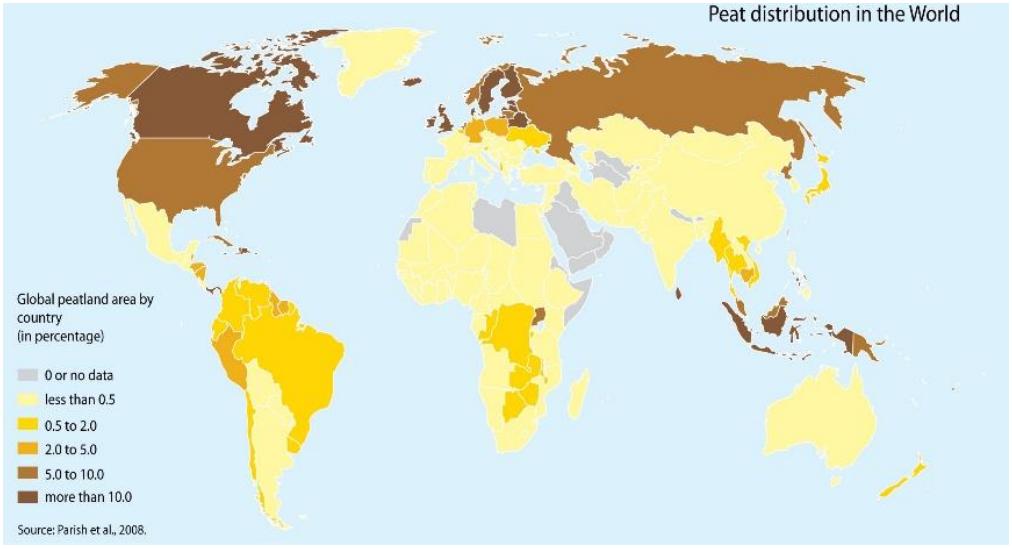


Figure 1.1. Global peat distribution.

Peatland area discovered in Malaysia is more than 10% of total around the world as shown in Figure 1.1 above. As cited by Ismail (2016), Davies et al. (2010) stated that

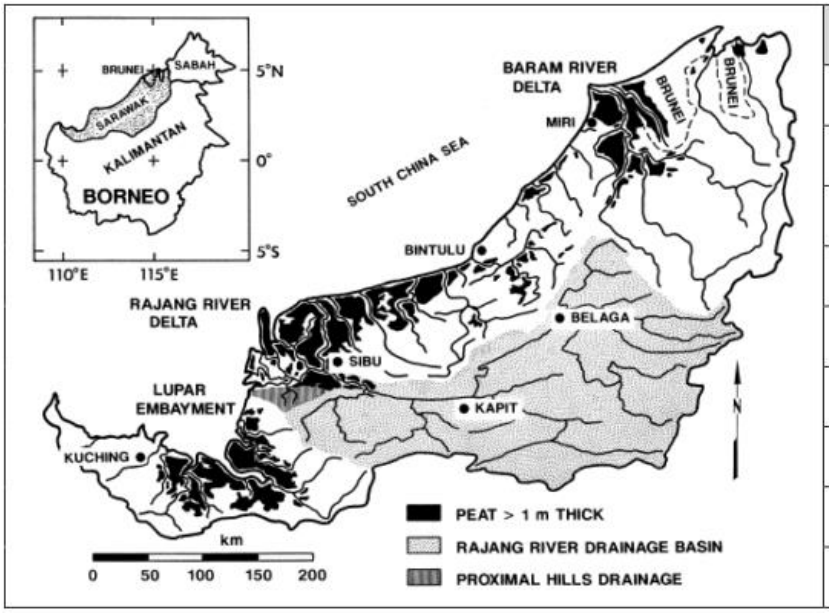
about 2.45 million ha (7.45%) of total land area in Malaysia is covered with peat or organic soils. Sarawak holds the largest area with about 1.7 million ha (69%) peatland area, 0.6 million ha (26%) in Peninsular Malaysia while 0.1 million ha (5%) of peatland area in Sabah. During past few decades, the demands on development of land were expanded into the swamp and deep peat areas which cannot be avoided (Sa 'don, Karim, Jaol, & Lili, 2015). Thus, ground improvement must be made.

There are various ground improvement techniques including removal and replacement method, preloading and drainage method, in – situ densification method, soil stabilization method and soil reinforcement method. However, the choice of these methods are influenced by some factors such as time factor, depth of the soil to be treated, types of soil, costs, etc. For peat soil, it is impossible to remove and replace the peat soil of about more than 6 m depth and some of these method are very expensive. Stabilization using chemical agent are more economical and easier to conduct on site. Plus, the chemical agent or additives used for stabilization are cheaper and easier to get in the industry.

For chemical stabilization of peat soil, the most common additives used are cement, fly ash, pond ash, and lime. Ismail (2016) stated that there have been few studies on peat stabilization using combined additives such as cement with lime (Said & Taib, 2009), quicklime and fly ash (Kolay et al., 2011) and also lime with rice husk ash (Vishwanath et al., 2014).

1.2 Problem statement

Increasing demand of land for construction and development caused peat soil could not be avoided. Peat soils are known as one of the problematic soils which found scattered in most areas of Sarawak. In Sarawak, peat covers about 1.7 million hectares and its distribution areas are shown in Figure 1.2.



Division	Area (ha.)
Kuching	23 059
Kota Samarahan	192 775
Sri Aman	283 076
Sibu	540 800
Sarikei	169 900
Bintulu	146 121
Miri	276 579
Limbang	25 300
TOTAL	**1 657 600**

Figure 1.2. Peat distribution in Sarawak.

Peat distribution in Sarawak is mainly in lowland area and along the coast. Sa'don et al., (2015) stated that most of Sarawak's peatlands are found in the central region of the State, specifically in Sibu division as shown in Figure 1.2. Peat mostly found on the top surface of the soils near to the ground water table and sometimes in certain cases as deep deposits. High moisture content in peat is the main factor contributing to the characterization of peat with low bearing capacity and bulk density (Sa 'don et al., 2015.). Due to some characteristic of peat such as high compressibility and long-term settlement, peat is incapable of carrying excess weight, as it settle down very quickly.

One of the case studies in Malaysia was in Sibu, Sarawak. (Razali, 2013) highlighted that the formation of peat in some parts of Sibu are well over 10 meters in depth. According to Duraisamy, Huat, & Aziz (2007), ground subsidence on peat land in Sibu town has resulted in negative gradients to drainage. Figure 1.3 and 1.4 show the settlements and ground subsidence occurred at housing areas in Sibu, Sarawak. This problem mainly caused by either uncontrolled land filling or ground water lowering due to over – drainage which may endangered the occupant's life.

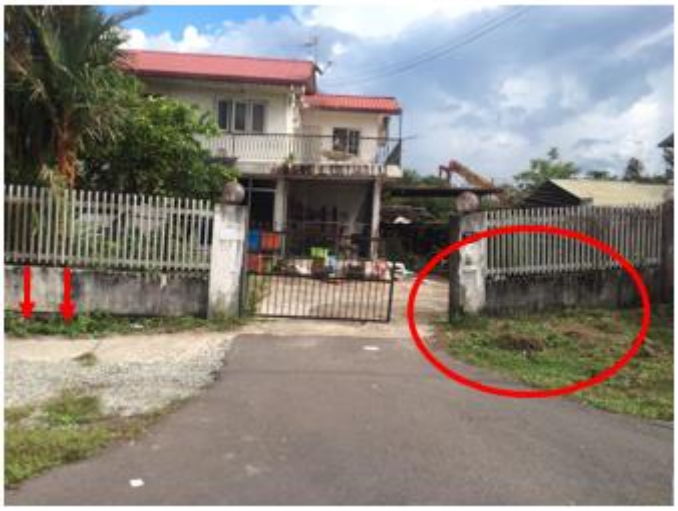


Figure 1.3. Settlement at housing area located at Jalan Oya, Sibu.

Figure 1.4. Ground subsidence at housing area in Sibu town. (Duraisamy, Huat, & Aziz, 2007)

With the increasing demand of land, it is difficult to avoid construction on peatland area. Thus, it is important to improve the strength of the peat soil first before the construction can start. Kolay, Sii, & Taib (2011) mentioned that deep stabilization technique is often an economically attractive alternative. The deep stabilization technique or deep soil mixing (DSM) method helps to achieve significant improvement of mechanical and physical properties of the existing soil, which after mixing with cement or other additives.

Chemical stabilization method is used in this study using different additives such as peat with cement and peat with fly ash and lime. Few studies have been done before with different period of time for curing and water to additives ratio. The best strength

results obtained with longer curing period at certain water to additives ratio. Thus, this research study concentrates on longer curing period by using the best water to additives ratio obtained from previous studies.

1.3 Objectives of the study

This study aims to improve the compressive strength of amorphous peat with a longer curing period after stabilization with chemical additive.

The specific objectives of this study are:

1) To compare the impact of various water to additive ratio on the stabilized peat.
2) To analyse the geotechnical properties of the stabilized peat via UCS test.

1.4 Scope of the study

This study concentrates on the stabilization of amorphous peat or known as highly decomposed peat obtained from Jalan Kampung Meranek, Kota Samarahan using different types of stabilizer. Type of stabilizer used in this study are cement and fly ash with lime. These type of stabilizers were chosen based on previous studies which recommended to extend the curing period of the stabilized peat. This study also concentrates on increasing the strength in the stabilized peat using the suitable water to additives ratio. The peat was stabilized in a laboratory condition and its natural moisture content maintained. The physical properties of the peat such as moisture content, specific gravity, and liquid limit will be obtained and utilized in performing the stabilization. Then, the stabilized peat will be tested using Unconfined Compressive Strength (UCS) test.

1.5 Significance of the Study

The findings of this study are important in order to be able to determine the best water to additive ratio to obtain the maximum strength of stabilized using the chemical stabilizer chosen. This can be used to improve the properties of peat soil and solved the problems existing in construction on soft soil.

1.6 Organization of Thesis

This thesis consist of 5 chapters. Chapter 1 represents the general information of the study including its background, problem statement, significance of the study and the organization of the thesis.

Meanwhile, all the reviewed literature from the previous study to obtain the information are presented in Chapter 2. In this chapter, topics such as type of peat soils, soil stabilizations, type of stabilizer used, water to additive ratio used and comparison on strength properties from previous studies are also discussed.

Chapter 3 provides the research methodology and discuss on the overall experiment program including laboratory test in detail. This chapter also includes the sampling of peat and laboratory tests performed to classify the soil and to determine the engineering properties of peat.

Chapter 4 represent the result and analysis of the study. The UCS test result and failure condition obtained are discussed in this chapter. In addition, the optimum water to additive ratio obtain are showed, and the comparison between the best ratio will be discussed.

Last but not least, Chapter 5 presents the conclusion of overall results and recommendation to improve this study will be stated.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter review the existing literature may related on many components. The first part covered on the characteristic and the information of the peat soil specifically on the amorphous peat. Then, followed by soil stabilization of amorphous peat using cement and soil stabilization of amorphous peat using fly ash and lime with different water to additive ratio. In addition, the comparison on strength properties from various peat stabilization are also included. The properties of the type of stabilizer used also discussed in this chapter.

Generally, before construction being implemented, there are many aspects to be considered such as the type of soil and the stability of the soil to ensure the safety of construction. Instability of the ground may damage the quality of construction and can cause building to collapse. Therefore, soil improvement is needed to reduce the instability and settlement problem that always happen during the construction on the peat soil. Stabilization of soil is a way to gain the strength and stability of the soil. One of the methods that can be used to improve the soil is chemical stabilization, which improves the physical properties of the soil by adding a chemical agent such as cement, fly ash, lime and many more. Different type of stabilizers may give different improvement on the soil properties depending on the properties of the stabilizer, amount used and other factors.

2.2 Definition and formation of peat

Peat is a type of soft soil composed of high content of fibrous organic matters and is produced by the partial decomposition and disintegration of mosses, sedges, trees, and other plants that grow in marshes and other wet place in the condition of lack of oxygen (Kazemian, Huat, Prasad, & Barghchi, 2011). Peat also contain high organic content, usually more than 75% which comes from partially decomposed and disintegrated plant. Kalantari & Prasad (2014) stated that peat is an accumulation of partially decomposed and disintegrated plant remains under conditions of incomplete aeration and high water content.

Peatland or wetland or also known as peat swamp because of its water table, which close to the peat surface throughout the year and fluctuates with the intensity and frequency of rainfall. Construction Research Institute of Malaysia (CREAM) (2015) highlighted that the build – up of layers of peat and the degree of decomposition depend principally on the local composition of the peat and the degree of waterlogging. According to Leete (2006), the formation of peat swamp formed in three stages as shown in Figure 2.1. At the beginning, the soils or dead vegetation are retained and waterlogged and after some time, the accumulation of organic matter from nearby trees and leaves occurs and the rate of decomposition slows down due to poor aeration as shown in the second stage where the water starts to change colour to brownish black. After a long time has passed, the peat layer is then formed.

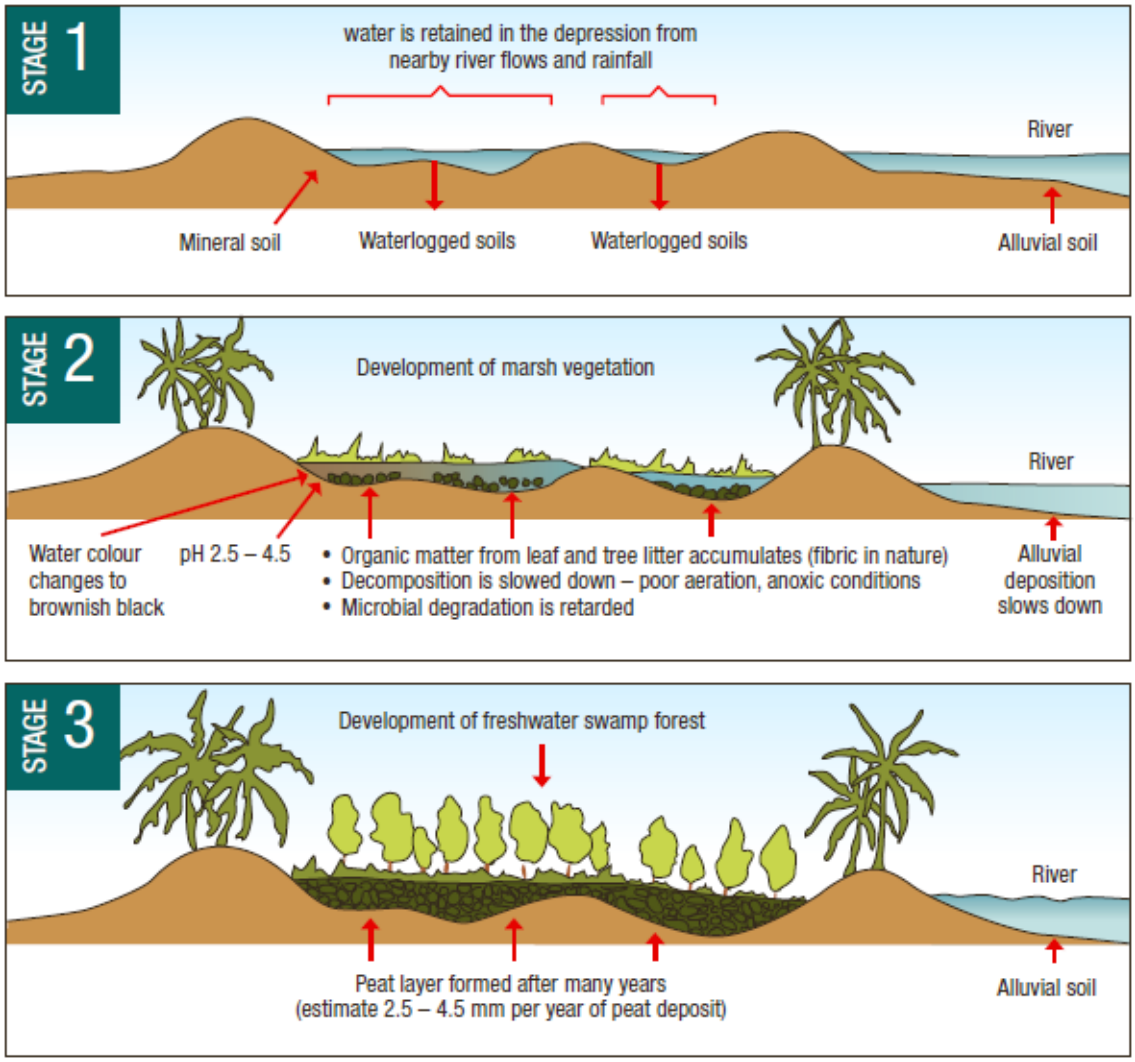


Figure 2.1. Peat swamp formation. (CREAM, 2015)

Peat acts as a natural sponge, retaining moisture at times of low rainfall but, because it is normally waterlogged already, with a very limited capacity to absorb additional heavy rainfall during periods such as tropical monsoon (CREAM, 2015). Peat accumulates whenever the condition are suitable where there is an excess of rainfall and the ground is fully undrained. Moreover, Kazemian et al., (2011) stated that the content of peat may differ from location to location due to factors such as origin of fiber, temperature, and degree of humification.

Peat are often referred as problematic soil due to its low shear strength, high compressibility, and high water content. CREAM (2015) mentioned that in the tropics like Malaysia and Indonesia, peat deposits also occur in both highlands and lowland areas which generally known as valley peat and basin peat respectively. The lowland or basin peat is more extensive and usually found in the inward edge of the mangrove swamps