GROUND IMPROVEMENT METHOD USING RUBBER SHREDDED AND ACRYLONITRILE BUTADIENE STYRENE

FATIN NUR AYUNI BINTI ABD AZIZ

SCHOOL OF CIVIL ENGINEERING
UNIVERSITI SAINS MALAYSIA
2017

Blank Page

GROUND IMPROVEMENT METHOD USING RUBBER SHREDDED AND ACRYLONITRILE BUTADIENE STYRENE

By

FATIN NUR AYUNI BINTI ABD AZIZ

This dissertation is submitted to

UNIVERSITI SAINS MALAYSIA

As partial fulfilment of requirement for the degree of

BACHELOR OF ENGINEERING (HONS.)
(CIVIL ENGINEERING)

School of Civil Engineering,
Universiti Sains Malaysia

June 2017

SCHOOL OF CIVIL ENGINEERING
ACADEMIC SESSION 2016/2017

FINAL YEAR PROJECT EAA492/6
DISSERTATION ENDORSEMENT FORM

Title: GROUND IMPROVEMENT METHOD USING RUBBER SHREDDEDAND ACRYLONITRILE BUTADIENE STYRENE

Name of Student: FATIN NUR AYUNI BINTI ABD AZIZ

I hereby declare that all corrections and comments made by the supervisor(s) and examiner have been taken into consideration and rectified accordingly.

Signature:

____

Date :

Approved by:

____

(Signature of Supervisor)

Name of Supervisor:

Date :

Approved by:

____

(Signature of Examiner)

Name of Examiner:

Date :

ACKNOWLEDGEMENT

I would like to express my gratitude to those people who in one way or another contributed and given me the possibility to complete this study. First and foremost, I would like to thank School of Civil Engineering that has provided all equipments and tools needed to conduct my study. I also want to thank my supervisor, Prof. Dr. Fauziah Ahmad for her kindness, guidance and support. Throughout the process of completing this research, she was very concern about my suggestion and has guided me all the way of this study.

Apart from that, not to forget to special gratitude to technical staff Mr. Dzauddin Zainol Abidin and Mr. Muhamad Zabidi Yusuff @ Md. Yusuff who have provided me guidance in conducting laboratory test during this study. Without their help, I believe all the experimental laboratory work will not run smooth as it should be. Furthermore, I would like to thank my course mates, Nur Haziqah Binti Mohd Hamid and Nurul Juliyana Binti Dinail, for their support, help and willingness to share some ideas and thus enable me to accomplish objective of this study.

Last but not least, I would like to thank my beloved family especially to my mother Rosminah Ahmad and my father Abd Aziz Yaakup for their constant and support, inspiration and encouragement during this project. Also very special thanks to all my friends and everyone who has made contribution either directly or indirectly in order to finish up this study until the end.

ABSTRAK

Penduduk Malaysia semakin meningkat dengan pesat dari tahun ke tahun. Dengan pertubuhan penduduk, penggunaan tanah akan meningkat dengan ketara dan banyak projek kejuruteraan awam akan dijalankan melibatkan tanah lembut. Penggunaan tanah lembut memerlukan penstabilan tanah untuk meningkatkan kestabilan dan juga mengelakkan pemendapan. Sebagai langkah penyelesaian, geotekstil telah digunakan sebagai langkah untuk meningkatkan kestabilan tanah yang lembut dan juga mengurangkan kos kerja tanah dikawasan yang bertanah lembut. Kaedah yang diselidik disini ialah penggunaan *rubber shredded* dan *acrylonitrile butadiene styrene* yang digunakan sebagai bahan tambah dalam tanah untuk kestabilan tanah. Penyelidikan yang dijalankan adalah untuk mengkaji kesesuaian penggunaan *rubber shredded* dan *acrylonitrile butadiene styrene* yang dicampurkan dengan tanah liat dan tanah merah. Penyelidikan ini juga mengkaji kekuatan tanah yang tidak dicampurkan dengan bahan tambah berbanding yang dicampurkan dengan bahan tambah menggunakan ujian tiga paksi dibawah ujian terkukuh tidak bersalir.

ABSTRACT

Malaysian citizen are increasing rapidly year by year. As the population growth, land use will increase significantly and there will be more civil engineering project will be carried on soft soil. Soft soil needs ground improvement method in order to stabilize the soil and prevent uneven settlement. As the solution, geotextiles are used to improve stability of the soil and reduce cost of constructing earthwork over such soils. Method used for this research was rubber shredded and acrylonitrile butadiene styrene that mixed with soil in order to stabilize the soil. This research was to investigate suitability uses of rubber shredded and acrylonitrile butadiene styrene as an additive to clay and laterite. This research also investigates strength of the soil with and without additive using triaxial test under consolidated undrained.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ABS	**A**crylonitrile **B**utadiene **S**tyrene
BS	**B**ritish **S**tandard
PB	**P**oly**B**utadiene
SAN	**S**tyrene **A**crylonitrule Copolymer
PC	**P**oly**C**arbonate
PBT	**P**oly**B**utylene **T**erephthalate

NOMENCLATURES

Gs	Specific gravity
Ms	Mass of solid
V	Volume
Vs	Volume of solid
Vm	Volume of mould
ρw	Density of water
ρs	Density of solid
γ	Unit weight
γd	Dry unit weight
w	Percentage of water content

CHAPTER 1

INTRODUCTION

1.1 Overview

Malaysia vision was to be fully developed country in year 2020. Many development activities that are currently in progress in order to be fully developed country. According to Department of Statistic Malaysia as the fairly strong momentum of project awards has been sustained in the last few years, the construction sector remained the fastest growing economic sector in 2015 the RM260 billion of development expenditure under the 11th Malaysia Plan (2016-2020) represents a 16% increase from the previous plan, which bodes well for the growth trajectory of the construction industry. As the development increases, land use will increase significantly including problematic area such as soft soil. The construction of roads over soft ground, such as peat, presents considerable technical challenges (Winter, 2014). The soft soils and other compressible soils are quite challengeable subject normally face geotechnical engineers (Al-Ani et al., 2014).

Soft soil was considered problematic due to their poor mechanical properties, such as small bearing capacity and long-term settlement under surcharge load (Yin and Yu, 2009). According to Asha et al., (2012) it was necessary to develop new innovative ground improvement techniques, which should be technically feasible and economically viable for the applications in civil engineering. In order to overcome problematic soil, many researchers have study ground improvement techniques. In the absence of appropriate ground improvement excessive settlement and lateral movement adversely affect the stability of buildings and port and transport infrastructure including highway and rail embankments built on such soft ground (Indraratna et al., 2014).

1.2 Problem Statement

Geotechnical engineers are often faced with challenges due to fast development in different places of the world, and for economic reasons they have to deal with difficult types of soils. The soils, which upon loading undergo great deformation for a long period of time, are of great interest for soil engineers (Elsayed et al., 2011). Often a site was chosen for construction irrespectively of its geotechnical suitability but for its location. Houston et al., (2001) did his study on problematic soil and he observed the effect of wetting include loss of apparent cementation, volume change, and loss of shear strength on problematic soil.

Problematic soil can cause several undesirable geotechnical properties such as low bearing capacity and high compressibility. Huat, (1998) observed an embankment was to be built to about 3.2 m high above original ground level, inclusive of a 1.5 m surcharge. Site clearing was commenced in early January 1992 followed by placement of geotextile separator layer with 400 mm thick sand blanket. Earth filling was commenced in early March 1992 and was completed to final level by midst July 1992. Five days later the embankment collapse without prior sighting of any tension crack due to construction on soft soil.

Hence, increase shear strength of soil was important to reduce failure on construction. In order to increase shear strength, many researches has come out with soil improvement method. According to Schaefer et al., (2012) soil improvement method has developed markedly over the past five decades to the point where they are almost routinely used in geotechnical design and construction. The method depends on type of soil condition. Ahmad et al., (2010) did study using oil palm empty fruit bunch (OPEFB) to stabilize silty sand. They reported that, OPEFB can significantly increase the peak shear strength of silty sand soil but they faced problem on biodegradation of OPEFB. Therefore, this research will contribute to produce another method using rubber shredded, and acrylonitrile butadiene styrene due to its take longer time to decomposed .

1.3 Objectives

In order to reduce failure on soil, research was needed to investigate method that increase shear strength of soil. In this thesis, a few objectives have been set up to present a research that conducted. Objectives of the research are:

1. To identify characteristic and behaviour of Sungai Dua clay and Bandar Baru laterite.
2. To determine shear strength and behaviour of soil with and without additive using triaxial test.
3. To compare strength of soil with and without additive using triaxial test.

1.4 Scope of study

Research of this study was focused on Sungai Dua clay and Bandar Baru laterite soil. Characteristic of soil was figured out and the properties of soil will be improved. The research can be divided into two stages; first, identify characteristic and behaviour of Sungai Dua clay and Bandar Baru laterite soil. Various laboratory tests will be carried out to investigate the soil's engineering characteristic. These include:

I. Mechanical Analysis (Sieve and Hydrometer)
II. Specific gravity
III. Proctor test
IV. Atterberg Limit

Second stage, determine shear strength of Sungai Dua clay and Bandar Baru laterite soil without additive using triaxial test and determine the shear strength and behaviour soil with additive using triaxial test.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

Soft soil was well known as very challenging to deal with. It was because the behaviour of soft soil was low shear strength and high compressibility and low permeability. During construction or after construction phase many engineering problem might be occur in the form of slope instability, bearing capacity failure or excessive settlement (Mohamad et al., 2002).

Clay was the one of soft soil. Natural clay usually contains some silt, which is also a fine-grained soil. There are numerous ground improvement been used in worldwide. Recent development in soil improvement include vibratory methods, new injection techniques for grouting and chemical mixes, reinforced soil, soil nailing, rock bolting and the use of geotextile.

Soil with low bearing capacities underlying high or heavy structures are always problematic from geotechnical engineering viewpoint. The problems that involve are subsiding of superstructure, failure of the underlying soil and liquefaction-based settlement. These precautions can be taken, by improving the properties of the soil either by mechanical or chemical stabilization.

The primary objective of this study was to examine the potential of rubber shredded and acrylonitrile butadiene styrene as soil additive for stabilizing Sungai Dua clay and Bandar Baru laterite soil. The characteristic and geotechnical properties of

Sungai Dua clay and Bandar Baru laterite soil are first studied and the results will be compared with the added rubber shredded and acrylonitrile butadiene styrene.

2.2 Challenges in Construction on Problematic Soil

According to (Mohamad et al., 2002), there are several cases regarding problematic soil in Malaysia.

2.2.1 Hospital Tengku Ampuan Rahimah Integration Quarters in Klang, Selangor

In this project, engineering problems was encountered during the construction stage. Installation of piles was commenced over soft ground right after site clearing without preparation of proper working platform. Upon completion of piling work, most of the installed piles were found to be deviated from original position after some times. Piles were also found to be severely tilted and damaged at the location of the proposed lift pit. The main cause was due to the displacement of soft ground as results of the moving jacked-in machine and excavation work for lift pits. In order to comply with standard requirement of PWD for pile installation using Jacked – in method, the total weight of the machine used must be approximately three times of the pile design capacity which is equivalent to about 260 metric ton. Such a heavy load that imposed on the surface of the ground had triggered vertical and horizontal displacement of the soil. Due to the existence of thick soft compressible layer at the site, the installed piles were expected to be pushed away by the displaced soil as it was lowly restrained in the horizontal direction.

2.2.2 Core Facilities Building of Polytechnic Kota Kinabalu (PKK), Sabah

From the boreholes result indicated the presence of fill material at the site with a thickness of about 7.2m. This layer is underlain by 10.6m of very soft to firm clayey sandy silt with some organic matters. A hard weathered siltstone and very poor weak sandstone was encountered at the depth of about 18.0m to 20.0m onward measured from the ground level. Based on the ground settlement monitoring records carried out from September – December 2005, a total ground settlement of about 130mm has been recorded, which equivalent to be about 103mm/ year. Therefore, it was concluded that the ground settlement within the building compound was still active at time of investigation. Depending on the actual thickness of soft compressible layer and height of fill at the site, a targeted 90% degree of consolidation expected to be achieved within 9 – 13 years after completion of the earthwork.

A separate settlement monitoring on columns also recorded a maximum reading of about 52mm settlement within a period of 15 months. The result of column settlement monitoring records had indicated that columns of Core Facilities Building had settled at different rates. Therefore, the major cause of the cracks is expected to be trigger by differential settlement that occurred on the foundation of the building.

2.3 Clay

The variation of stress–strain state induces changes in the permeability of clayey soil and then affects the properties of seepage and consolidation. Clay soils are commonly formed by the slow deposition of clay particles in water such as lacustrine or marine bodies. Within these environments, the particles settle and eventually consolidate to form soil strata. During the settlement process the water chemistry and clay mineralogy will greatly influence the interaction between particles, whether particles will settle individually or in clusters known as flocs. Initially the structure of the soil will reflect the settling behaviour such as flocculated soil will have a more open structure, with a greater volume of voids between particles, compared to a dispersed soil (Newson and Duliere, 2003).

Clay consist of a variety of phyllosilicate minerals rich in silicon and aluminium oxides and hydroxides which include variable amounts of structural water. In geotechnical engineering, it has long been known that swelling of expansive soil caused by moisture change result in significant distresses and hence in sever age damage to overlaying structures. Expansive soils are known as shrink-swell or swelling soils. The greatest problem occurs in soils with high montmorillonite content and such soils expand when they are wetted and shrink when dried (Ming, 2008). Clay mineral has very high adsorptive capacity for water and hence presents engineering problems.

Ming (2008) cited that mechanism of swelling was complex and in influenced by number of factor such as:

I. Type of and amount of clay mineral present in the soil
II. Specific surface area of the clay
III. Structure of the soil
IV. Valence of the exchangeable cation

However shrinkage occurs on evaporation of water. This problem swelling and shrinkage has caused damage to many lightly loaded civil engineering structures (Ming, 2008).

2.4 Laterite

Ming (2008) cited residual weathered soils formed in regions of topical volcanic activity and continuous wet climate with average annual rainfall excess of 60 inches. They have high natural water content, high liquid limits, low natural densities that was

320-1120 kg/m^3 and crumble structures. These soils are low compressibility, highly permeable and high fiction angles. The crumbly or granular nature of these soils appears to derive mainly from free iron oxides which are absorbed on the surface of the clay minerals.

Laterite soils are commonly in tropical latitude and being readily available at low cost and often use for road construction. However, they frequently do not meet specification requirements, commonly having too high fines percentage and hence being too plastic (Ming, 2008). Being too plastic make soil stiff and failed.

According to Ming (2008), laterite was highly weathered tropical soils, rich in secondary oxides of any or a combination of iron, aluminium and manganese. Laterite soils are residually weathered soils formed in regions of recent volcanic activity and/or continuous wet climate with an average rainfall generally above 1500mm. It was problematic in road and structure construction.

2.5 Tire shredded

Tire shredded was widely used in geotechnical engineering to increase shear strength of the soil as an improvement techniques. According to (Yoon et al., 2006), performance mixtures of tire shredded with sand in embankment fill construction was quite satisfactory. Advantages of the material are lightweight, relatively cheap, easy to compact, free-draining and relatively incompressible.

According to (Rao and Dutta, 2006) mechanically obtained tire shredded exhibit a very high angle of shearing resistance. The observed angle of repose has been found to range from 37 inches to 43 inches a loose condition to values as high as 85 inches when compacted. For tire chips 50–150 mm in size, a friction angle of 30 inches in a 305 mm direct shear test, using the shear resistance at 25 mm horizontal displacement as failure. Pure chips have a friction angle of 20 – 35 inches and a cohesion intercept of 3 –11.5 kPa in large size direct shear tests.

2.5.1 Tire shredded mechanism

According to (Rao and Dutta, 2006) tire shredded possess interesting technical properties that could be beneficially used in civil engineering applications. Some characteristic properties of tire shred materials are:

I. Low density
II. High elasticity
III. Low stiffness
IV. High drainage capacity
V. High thermal insulation capacity

These properties open up possibilities for utilisation of the material in an innovative manner.

2.5.2 Tire density

According to (Moo-Young et al., 2003) compact density such as the grain density of the individual tire shreds, of tire shredded ranges from 1.08-1.27 t/m^3. Compact density was slightly higher than the density of water and thus tire shredded will sink if placed into water. The bulk density of the tire shredded ranges from 420 kg/m^3 to 980 kg/m3 in the stress interval 0-400 kPa. Results of other studies show similar values, 450 to 990 kg/m^3 in the stress range 0-400 kPa. At no vertical stress the