THE EFFECT OF CATALYST ON SOIL STABILIZATION BY APPLICATION OF LIME

WAN EWIRDA BINTI WAN ZALIK

A project report is submitted in fulfillment of the requirements for the award of the degree of Master of Engineering (Civil - Geotechnics)

Faculty of Civil Engineering
Universiti Teknologi Malaysia

NOVEMBER 2009

Special dedicated to..

My beloved parent, wea & ummi...my siblings...my dear...

also to my nice supervisor...

and UTM... ☺

ACKNOWLEDGEMENT

I would like to express my sincere and deepest gratitude to my supervisor, Prof Dr Khairul Anuar b. Kassim for giving me an opportunity to pursue this project with entirely supervision, guidance, valuable suggestions, constant support and encouragement. Without his continued support and sharing, this thesis would not have been well presented here.

My appreciation and thanks are also extends to all the staff of Geotechnical Laboratory, Faculty of Civil Engineering, UTM especially to Mr. Zulkifli who provide assistance at various occasions. His views and tips are useful indeed. Unfortunately, it is impossible to list all of them in this limited space. I am also grateful to all my family members especially my parent, my siblings and my dear for their understanding and encourage me all the time in successfully producing this thesis.

I am also indebted to the librarians of Perpustakaan Sultanah Zanariah, UTM for their assistance in supplying the relevant literatures to complete this thesis. Last but least, I wish to express my sincere appreciation to all the people who has direct or indirect participates through out the preparation of this thesis. Thank you very much.

ABSTRACT

Soft cohesive clays are normally associated with large settlements and low strength. Various techniques are available to reduce the problem. One of the low cost techniques is to modify the soil with lime in-situ to make it workable for construction and allow it to increase in strength by pozzolanic reactions between lime and clay minerals. The addition of lime to a soil has a pronounced effect on its physical and chemical properties. It is known to be an effective stabilization method for clayey soil. However, due to the variation of soil minerals and clay fraction, the degree of pozzolanic reactions varies. Addition of catalyst i.e. zeolite may improve the performance of lime stabilization. There are two types of zeolites which are natural zeolite and synthetic zeolite. A series of laboratory tests has been carried out to investigate the effect of zeolite on the performance of lime stabilization. Unconfined Compressive Test on 36 sets of samples has been carried out for 0,7,14, 28 and 56 days of curing. The addition of synthetic zeolite in lime-kaolin stabilized soil has increased the soil strength by 255% at 56 days curing period at the design mix of kaolin + 6% lime +15% zeolite. The higher value of UCS indicates that zeolite is an effective catalyst to enhance lime stabilization.

ABSTRAK

Tanah liat berjelekit selalu mengalami pengenapan yang besar dan mempunyai kekuatan ricih yang rendah. Terdapat pelbagai kaedah untuk mengurangkan masalah tersebut. Salah satu kaedah yang ekonomi ialah pengubahsuaian insitu dengan kapur terhidrat untuk meningkatkan kebolehkerjaan tanah dan kekuatan tanah melalui tindakbalas pozzolanik antara kapur dan garam-galian di dalam tanah liat. Penggunaan kapur dalam penstabilan tanah liat telah diketahui umum dapat memberi kesan yang baik terhadap struktur fizikal dan kimia tanah tersebut. Walaubagaimanapun, merujuk kepada kepelbagaian garam galian tanah dan struktur dalam tanah tersebut, kadar tindakbalas pozzolanik adalah berbeza di antara setiap jenis tanah. Pertambahan mangkin seperti zeolite adalah sangat efektif untuk meningkatkan prestasi penstabilan batu kapur. Terdapat dua jenis zeolite iaitu zeolite semulajadi dan zeolite sintetik. Suatu siri ujikaji makmal telah dijalankan untuk memastikan kesan pertambahan zeolite ke atas penstabilan kapur. 36 set sampel Ujian Mampatan tak Terkurung telah dijalankan setelah sampel-sampel di awet selama 0, 7, 14, 28 dan 56 hari. Pertambahan zeolite sintetik dalam penstabilan tanah-kapur telah meningkatkan kekuatan tanah sebanyak 255% setelah di awet selama 56 hari pada campuran optimum kaolin + 6% kapur + 15% zeolite A. Peningkatan kekuatan tanah menunjukkan pengggunaa zeolite dalam penstabilan tanah-kapur adalah efektif.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Research Background

Soil stabilization using lime or cement has long been used to improve the handling and mechanical characteristics of soils for civil engineering purposes (Sherwood, 1993). Stabilization must then be considered as having both a physical and aspect involving changes to the mechanical properties of the material, and a chemical aspect involving changes to the form and mobility of the contaminants present. The creation of full lime stabilization requires a significant percentage of lime to be added to and mixed with the clay, an adequate understanding of the reaction processes and a good knowledge of the compaction process. It thus requires careful design and close attention to detail during the construction process in order to ensure that the long-term benefits are achieved.

The important of a basic decision must therefore to take into account whether to use the original site material and design to standard sufficient by its existing quality or ; to replace the site material with the superior material or ; create a new site material that suite to the standard requirement by alter the properties of existing material (Ingles, 1972). The stabilizing effect depends on the reaction

between lime and soil minerals. The main effect of this reaction is an increasing of shear strength and bearing capacity of the soils.

Soil can be stabilized by the addition of small percentages, by weight, of lime, thereby enhancing many of the engineering properties of the soil and producing an improved construction material. Nowdays, there is a lot of discussion concerning the pozzolanic activity of natural zeolite. Zeolite tuffs have been widely used, as mixtures with lime, in construction since Roman times. Zeolitized tuffs displays excellent pozzolanic activity. This behavior has been exploited, unconsciously, since at least at the beginning of this century.

1.2 Problem Statement

Soil stabilization with lime products will turn unsuitable soils into useful construction materials that can be easily placed and compacted to form part of the temporary or permanent works. Previous works on lime stabilization proved that some type of soil may improved but some may not. This is due to the variation in clay fraction and soil minerals. To extend this finding, lime with addition of catalyst were examined for soil stabilization. Addition of catalyst such as zeolite may improve the long term performance of lime stabilization due to the enhancement in the pozzolanic reaction. Optimum mix of lime and zeolites will be established for effective stabilization.

1.3 Objectives

Generally, the objectives of this study are:

i. To investigate the effectiveness of lime-zeolite in stabilizing soil.
ii. To establish the optimum mix of lime and zeolite additives for effective soil stabilization.
iii. To compare two types of zeolite for effective stabilization.

1.4 Scope of The Study

This study focused on the strength characteristic of the soil by using unconfined compression test. The soils that been used in this study are kaolin. Several tests that have been conducted on soil samples are to identify the engineering properties of samples. Lime that have been used in this study is calcium hydroxide $(CaOH)_2$, also known as hydrated lime or slake lime, since it is not too exothermic and harmful to the skin compared with quicklime. To extend this finding in application, various proportion of lime with additives of zeolite were examine for soil stabilization. There are two types of zeolite which is zeolite A (in powder form) and zeolite B (in granular form) will be used in this study. The concentration of lime were 6% whereas the zeolites are 5%, 10% and 15% performed on samples at curing periods of 0, 7,14,28 and 56 days. Compaction test and Unconfined Compression Test (UCT)also been conducted on the mixture of lime-zeolite.

REFERENCES

Aminaton Marto and Novrial, (1999). *The Effect of Lime-Soil Cylinders on Laterite Slope Model.* Fifth Geotechnical Engineering Conference (Geotropika 99), pp 223-233.

British Standard Institution, (1990). *Soils for Civil Engineering Purposes.* London: (BS 1377: Part 1)

British Standard Institution, (1990). *Soils for Civil Engineering Purposes.* London: (BS 1377: Part 2)

British Standard Institution, (1990). *Soils for Civil Engineering Purposes.* London: (BS 1377: Part 3)

British Standard Institution, (1990). *Soils for Civil Engineering Purposes.* London: (BS 1377: Part 4)

British Standard Institution, (1990). *Stabilized Materials for Civil Engineering Purposes.* London: (BS 1924: Part 1)

British Standard Institution, (1990). *Stabilized Materials for Civil Engineering Purposes.* London: (BS1924: Part 2)

C. D. F Rogers and S. Glendinning, (1997). *Improvement of clay soils in situ using lime piles in the UK.* Journal of Engineering Geology, Vol. 42, pp 243-257.

CDF Rogers, S. Glendinning and N. Dixon, (1996). *Lime stabilization*. Great Britain: The Cromwell Press, Welksham, Wilts, 183p.

Cheng Liu and Jack B. Evett, (2003). *Soil Properties: Testing, Measurement and Evaluation,* fifth Edition, New Jersey: Pearson Education Inc, 423p.

Chester I Duncan, Jr. (1998). *Soils and Foundations For Architects And Engineers*. South America: Kluwer Academic Publisher, 403p.

F.G Bell (1996). *Lime Stabilization of Clay Minerals and Soils.* Journal of Engineering Geology, Vol. 42, pp. 223-227.

G. Rajasekaran and S. Narasimha Rao, (2000). *Compressibility behaviour of lime treated marine clay.* Journal of Ocean engineering, Vol. 29, pp 545-559.

H.R Thomas, J.D McKinley, J.M Reid and K.P William, (2001). *Chemical Analysis of Contaminated Soil Strengthened by the addition of Lime*. Journal of Engineering Geology, Vol. 60, pp. 181-192.

James K.Mitchell, (1993). *Fundamentals Of Soil Behaviour*. New York: John Wiley & Sons, Inc, 437p.

J. M Reid and A. H Brookes, (1999). *Investigation of Lime Stabilized Contaminated Material.* Journal of Engineering Geology, Vol. 53, pp 217-231.

Khairul Anuar Kassim and Kok Chai Kern, (2004). *Lime Stabilized Malaysian Cohesive Soils.* Journal of Civil Engineering, Vol. 16, pp 13-23.

Khairul Anuar Kassim and Kok Chai Kern, (1999). *Mix For Lime Modification of Malaysian Cohesive Soils.* Fifth Geotechnical Engineering Conference (Geotropika 99), pp 235-244.

National Lime Association, (2006). *Technical Brief:Mixture Design And Testing Procedures for Lime Stabilized Soil*, October 2006, Arlington.

N.O. Attoh-Okine (1995). *Lime Treatment of Laterite Soils and Gravels-revisited*. Journal of Construction and Building Material, Vol. 9, No. 5, pp 283-287.

Raymond N. Yong and Vahid R. Ouhadi, (2006). *Experimental Study on Instability of Bases on natural and lime/cement-stabilized clayey soils.* Journal of Applied Clay Science, Vol. 35, pp 238-249.

Samuel Yariv and Harold Cross, (2006). *Organo-Clay Complexes and Interactions*. United States of America: Marcel Dekker, Inc, 688p.

S. Koslanant, K. Onitsuka and T. Negami, (2006). *Influence of Salt Additive in Lime Stabilization of Organic Clay*. Jouranal Of The Southeast Asian Geotechnical Society, pp 95-101.

S. Wild, J. M Kinuthia, G.I Jones and D.D Higgins, (1998). *Effect of partial Substitution of lime with ground granulated blast furnace slag (GGBS) on the strength properties of lime stabilized sulphate-bearing clay soils*. Journal Of Engineering Geology, Vol. 53, pp 37-53.

Th. Perraki, G. Kakali, F. Kontaleon, (2003). *The effect of natural zeolite on the early hydration of Portland Cement.* Microporous and Mesoporous Material 61, pp 205-212.