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EXPERIMENTAL STUDY ON RESILIENT MODULUS OF LIQUID SILICON DIOXIDE (SiO_2) STABILIZED SUBGRADE SOIL

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SESI PENGAJIAN: **2008/2009**

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Date : 10TH June 2009

EXPERIMENTAL STUDY ON RESILIENT MODULUS OF LIQUID SILICON DIOXIDE (SiO_2) STABILIZED SUBGRADE SOIL

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A project report submitted in partial fulfillment of the
requirement for the award of the degree of
Master of Engineering (Civil –Highway Engineering)

Faculty of Civil and Environmental Engineering
Universiti Tun Hussein Onn Malaysia

June 2009

"I hereby declare that this project report entitled "Experimental Study on Resilient Modulus of Liquid Silicon Dioxide (SiO_2) Stabilized Subgrade Soil" is the result of my own work except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree."

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Dedicated to;

To my beloved parents,
Mr.Arumugam & Mrs.Saraswathy

To my best sisters,
Pathma & Keeli

To my supportive brothers and brother in law,
Sugunanathan, Saravanan and Kumar

For all the love, care and support... ... ...

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ABSTRACT

Village and estate roads have failed to function due to damage at earlier stage of construction and this required frequent maintenance. Weak sub-grade is the basic factor of exponential damage. In order to overcome this problem, many procedures have been developed to improve the physical behavior (strength or stiffness) of the sub grade soil. One of the procedures is to incorporate a wide range of stabilizing agent, additives or conditioners. Silicon dioxide (SiO_2) is a water based sodium silicate which is currently being patented on application by Probase Manufacturing Sdn.Bhd. to stabilize subgrade soils. The main objective of this research is to determine the resilient modulus of the liquid SiO_2 stabilized sub grade soil at number of state conditions (i.e. density, moisture content and amount of stabilizer). Repeated triaxial load test was carried out at Highway Engineering Laboratory, UTHM. The specimens were prepared with maximum (100%), 90% and 95% dry density, optimum moisture content, 3% dry of optimum and 3% wet of optimum, and the amount of stabilizer was 4%, 8% and 12% of dry density of the soil. The specimens were cured for 0, 7, 14 and 28 days to determine the effect of curing days on the stabilized soil. The resilient modulus data were used to identify the best fit equation with the data. However typical pavement system analyzed using KENLAYER for non-linear elastic layer for fine grained soil; the equation applicable is the bilinear equation. Analysis of Variance (ANOVA) has been carried out to evaluate the level of significance effect of the state conditions on the stabilized soil. It has been found that density affects the resilient modulus of fine grained materials; however the magnitude of this effect is smaller compared to effect of moisture conditions. The addition of liquid SiO_2 stabilizer improves the stiffness (resilient modulus) of the soil and consequently, the optimum concentration is found to be 4% for sub grade stabilization through this study.

ABSTRAK

Jalan-jalan kampung dan ladang gagal berfungsi selepas pembinaan disebabkan oleh kerosakkan pada peringkat awal, maka penyelenggaraan kerap dilakukan bagi mengatasi masalah ini. Lapisan subgrade yang lemah menjadi punca utama berlakunya kerosakan pada jalan raya. Bagi mengatasi masalah ini, pelbagai cara telah diperkenalkan, antaranya ialah aplikasi bahan penstabil, bahan tambah dan lain-lain lagi. Silicon dioksida (SiO_2) merupakan bahan penstabil dalam bentuk cecair yang kini digunakan dalam proses penstabilan lapisan subgrade jalanraya yang diperkenalkan oleh Probase Manufacturing Sdn.Bhd. Objektif utama kajian ini ialah mengkaji modulus ketahanan tanah subgrade yang telah distabilkan dengan penstabil SiO_2 pada beberapa keadaan (i.e. ketumpatan tanah, kandungan air dan jumlah penggunaan bahan penstabil) yang berlainan. Ujian repeated triaxial load telah dijalankan di Makmal Kejuruteraan Jalanraya, UTHM. Spesimen disediakan dengan ketumpatan maksimum (100%), 95%, 90%, kandungan air optimum, 3% kurang dari optimum, 3% lebih dari optimum, dan bahan penstabil sebanyak 4%, 8% dan 12% dari berat kering tanah. Kesemua spesimen telah diawet selama 0, 7, 14 dan 28 hari untuk mengkaji kesan tempoh pengawetan terhadap tanah yang telah distabilkan dengan SiO_2. Data modulus ketahanan digunakan untuk menentukan persamaan konstitutif yang mempunyai penyuaian terbaik dengan data tersebut. Sistem jalanraya dianalisis menggunakan KENLAYER untuk lapisan kenyal yang tidak linear untuk tanah subgrade, tetapi hanya persamaan bilinear diaplikasi dalam sistem KENLAYER bagi tanah subgrade. Analisis of Variance (ANOVA) telah dijalankan bagi mengkaji kepentingan beberapa keadaan (i.e.ketumpatan tanah, kandungan air dan jumlah penggunaan bahan penstabil)atas tanah yang telah distabil. Melalui kajian ini, didapati ketumpatan tanah mempunyai kesan yang kecil terhadap tanah yang telah distabilkan jika dibandingkan dengan kandungan air. Penstabilan dengan

bahan penstabil SiO_2 meningkatkan kekerasan (modulus ketahanan) tanah subgrade, dan kepekatan optimum yang dikenalpasti melalui kajian ini ialah sebanyak 4%.

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LIST OF SYMBOLS

%	-	Percent
et al.	-	And other people
i.e.	-	In other words
UTHM	-	Universiti Tun Hussein Onn Malaysia
FKAAS		Fakulti Kejuruteraan Awam dan Alam Sekitar
km		kilometer
OMC		Optimum Moisture Content
JKR		Jabatan Kerja Raya
LVDT		linear variable differential transformer
LTPP		Long Term Pavement Protocol
UTM		Universal Testing Machine
ANOVA		Analysis of Variance
Mr		Resilient Modulus
σ_1		major principal stress or maximum axial stress
σ_2		minor principal stress
σ_3		confining pressure
σ_d		deviator stress
ε_R		recoverable (resilient) axial strain
kPa		kilo Pascal
k_1, k_2, k_3 and k_4		model parameter
R^2		regression coefficient
Pa		atmospheric pressure (100kPa)
PR		Poisson Ratio
E		Elastic Modulus
ε_v		Compressive Strain

ε_t		Tensile Strain
N_d		Allowable number of load repetitions to limit Permanent deformation
CBR		California Bearing Ratio
BS		British Standard
SiO_2		Silicon Dioxide
NaO_2		Sodium Oxide
Na		Natrium
Mg		Magnesium
Ca^+	-	Calcium ion
K^+	-	Potassium ion
Al_2O_3	-	Alumina
Fe_2O_3	-	Iron Oxide
Na_2O	-	Sodium Oxide
TiO_2	-	Titanium Oxide
CaO	-	Calcium Oxide

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CHAPTER I

INTRODUCTION

1.1 Introduction

Village roads and estate roads were vital components in the national road system. This road system has functioned as the source of transportation to transfer agricultural products from the farm or estates to the urban areas, where it is processed and sold. These road networks were important transportation mode and are regarded as an essential source for the development of rural areas.

According to Yoder (1995), "in most cases, the roads are used more than its capacity. This is due to lack of systematic and comprehensive maintenance. As the damage occurs at a very early stage, it affects the functionality of the village and estate roads. The damage occurs at faster rate whenever high numbers of heavy vehicles use the road frequently. The repercussion is that the roads do not function to the maximum years it was designed to last."