MECHANICAL BEHAVIOR OF SAND-TIRE CHIPS MIXTURE UNDER MONOTONIC LOADING

CHEW YUN LIEH

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

Faculty of Civil Engineering
Universiti Teknologi Malaysia

JANUARY 2013

To my beloved family and friends

ACKNOWLEDGEMENT

First of all I wish to express my sincere appreciation to my supervisor Prof. Dr. Aminaton binti Marto from the Faculty of Civil Engineering, Universiti Teknologi Malaysia for her information, valuable guidance and precious time in helping me to complete this Master Degree Project report. Her strong understanding in Geotechnical Engineering is very helpful in providing me a full understand on my Master Degree Project.

I wish to express my deepest gratitude to all the laboratory technicians in the Faculty of Civil Engineering, UTM who are very dedicated and helpful in assisting me during my laboratory works.

Last but not least, the moral supports and concerns from my family and friends are well acknowledged. Without the support and encourage from them completion this project would not be possible. I am so thankful to have them in supporting all the way through this project work.

ABSTRACT

The volume of used tire in the world is increasing tremendously every year due to the increase in population. With the increasing volume of used tire, it causes environmental and financial burden towards many regions all around the world. This volume of used tire will occupy landfills and may cause fire or provide breeding ground for mosquitos. Therefore used tire had been implemented into geotechnical engineering to create a sustainable future. In order to implement used tire in geotechnical engineering application a full understanding of the mechanical properties of used tire is required. This study aims to investigate the mechanical behavior of sand-tire chips mixture with 30% and 50% tire chips content under monotonic loading using triaxial test at confining pressure of 100, 200 and 300kPa. As the percentage of tire chips increased the cohesion tends to increase but decrease the friction angle. The shear strength of sand-tire chips mixture increased with the addition of tire chips are added into sand until a vicinity percentage of 30% and beyond that it tend to decrease. This is due to the addition of tire chips tend to behave more as a mass with sand inclusions rather than a reinforced soil. Besides that when the sizes of tire chip increased the shear strength tend to increase. Principally this is due to the friction between the sand and tire chips are reduced. When tire chips content increased elastic modulus has a tendency to decrease as a result of tire chip is an effective energy absorbent material. It is also observed that as the when confining pressure increase, the elastic modulus tends to increase.

ABSTRAK

Setiap tahun isipadu tayar yang digunakan dalam dunia semakin meningkat dengan pesat disebabkan oleh peningkatan dalam jumlah penduduk. Dengan jumlah yang semakin meningkat, ia merupakan satu beban kepada alam sekitar dan kewangan di seluruh dunia. Jumlah tayar yang tidak digunakan akan memenuhi tapak pelupusan dan boleh menyebabkan kebakaran atau menjadikan kawasan pembiakan nyamuk. Dengan itu tayar terpakai telah digunakan dalam bidang kejuruteraan geoteknikal untuk mewujudkan masa depan yang mampan. Untuk melaksanakan tayar terpakai dalam aplikasi kejuruteraan geoteknikal, pemahaman yang penuh pada sifat-sifat mekanikal tayar terpakai adalah amat diperlukan. Kajian ini bertujuan untuk menyiasat kelakuan mekanikal pasir-cip tayar dengan 30%, 50% kandungan cip tayar campuran cip di bawah pembebanan monotonic menggunakan ujian tiga paksi pengukuran tersalir pada tekanan mengurung 100,200 dan 300 kPa. Apabila peratusan cip tayar meningkat perpaduan akan cenderung meningkat tetapi mengurangkan sudut geseran. Kekuatan ricih pasir tayar cip campuran meningkat apabila cip tayar ditambah ke dalam pasir sehingga 30% dan melebihi itu ia cenderung untuk mengurang. Ini adalah disebabkan oleh penambahan cip tayar bertindak lebih sebagai jisim. Selain itu apabila saiz cip tayar meningkat kekuatan ricih cenderung pun akan meningkat. Ini adalah disebabkan geseran antara pasir dan serpihan tayar telah dikurangkan. Apabila kandungan cip tayar meningkat elastik modulus mempunyai kecenderungan untuk mengurangkan akibat cip tayar adalah bahan tenaga berkesan penyerap. Diperhatikan juga apabila tekanan mengurung meningkat tekanan modulus elastic juga cenderung untuk meningkat.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AS		Australia Standard
ASTM	-	American Society of Testing & Materials
BS	-	British Standard
CU	-	Consolidated Undrained
USCS	-	Unified Soil Classification System

LIST OF SYMBOLS

e_{max}		maximum density
e_{min}		minimum density
G_s	-	Specific gravity
D	-	Diameter
S	-	Shear strength
C	-	Cohesion intercept
Φ	-	Angle of internal friction
σ_1	-	Major principle stress
σ_2	-	Intermediate principle stress
σ_3	-	Minor principle stress
C_u	-	Coefficient of uniformity
C_c	-	Coefficient of curvature
ε_v	-	Volumetric strain
ε_a	-	Axial strain
σ'	-	Effective pressure
E	-	Elastic modulus

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The volume of used tire in the world is increasing tremendously every year due to the increased in population and this cause a major environmental problem. A large volume of used tire will occupy the crowded landfills and may cause fire or provide a breeding ground for mosquitos. Therefore action that had been taken by European Union in banishing the disposal of tires in landfills through the directive 1991/31/EC which applies to all the European Union countries. This directly promotes recycling of used tire in civil engineering and mainly geotechnics due to the advantages of lightweight, high vibration absorption, high elastic compressibility, high hydraulic conductivity and temperature isolation. Currently sand-tire chips mixture is widely used as lightweight material for the embankment body, as backfill of retaining wall, drainage layer, thermal or vibration insulation layer and reinforcement layer (Foose *et al.,* 1996, Pisarczyk, 2002).

Many researches had been conducted on the fundamental engineering properties of sand-tire chips mixture such as compaction characteristics, compressibility, permeability, shear strength, modulus of elasticity and poisson's ratio. Rao and Dutta (2006) studied the admixture of sand-tire chips in varying size and content. They concluded that as the content of the tire chips in sand increase the shear stress will indeed increase. Shahin *et al*. (2011), Zornberg *et al.* (2004), Lee *et al.* (2005) and Balachowski (2007) studied the mechanical properties of tire chips-sand mixture on triaxial tests analyzing the shape of the tire, tire content on the sand at different confining pressure and sand density. They found out that the maximum shear strength of the mixture is close to 35% of tire shred content.

Waste tire should be fully utilized in various sizes from the point of view of environmental. However the costs of cutting waste tire into various sizes also play an important role. It can be seen that additional costs are required to make tire in certain dimensions. Ghazavi and Sakhi (2005) studied on the influence of optimized tire shreds on shear strength parameters of sand. They reported that shred contents, shred width, shred aspect ratio for a given width, compaction and normal stress are influencing factors on shear strength of the mixtures. Dilation indeed occurs during shearing stage especially at high tire content and more compaction. Besides that they also reported that the optimization of aspect ratio of shred with the width of 2-4cm tends to increase the friction angle by 25%.

1.2 Problem Statement

In many industrialized country waste tire had been causing an enormous problem towards waste management engineer. Due to tire do not decompose, the way of disposing it have a tendency to pose a threat to the public health and also the environment for example occupying large volumes in already crowded landfills, waste tire storage can be a dangerous risk and waste tire dumps provide the breeding ground for vermin, rats and mosquitos (Gotteland, 2005). Indeed tire can be implemented into geotechnical and geo-environmental due to the unique properties for example durability, strength, resiliency and high friction resistance. All this are significant value for geotechnical design in improving weak shear strength soil. Besides that waste tire can also be substituted to virgin construction materials that are nonrenewable (Zornberg, 2004).

REFERENCES

Ahmed. I. (1993). *Laboratory Study on Properties of Rubber Soils*. Purdue University, Indiana, Joint Highway Research Project, Report No.FHWA/IN/JHRP-93/4.

Ahmed. T. and Lovell. C. W. (1995). *Rubber soils as lightweight geomaterial*.

American Society for Testing and Materials. *Test for Relative Density of Cohesionless Soils*. ASTM D2049-69.

Anbazhagan. P., Mamatha. M. (2011). Laboratory Characterization of tyre crumbs soil mixture for developing low cost damping materials. *International Journal of Earth Science and Engineering* ISSN 0974-5904, Volume 04, No 06 SPL, pp.63-66.

Balachowski. L. and Gotteland. P. (2007). Characteristics of tyre chips-sand mixture for triaxial tests. *Hydro-Engineering and Environmental Mechanics*, Vol.54 (2007), pp. 25-36.

Benda. C. C. (1995) *Engineering Properties of Scrap Tires Used in Geotechnical Applications*. Report No.95-1. Vermot Agency of Transportation, Montpelier, VT.

Braja M. Das. (1999) *Fundamental of Geotechnical Engineering*, Thomson learning.

British Standard Institution (1990). *Methods of Test for- soils for civil engineering purposes*, BS1377-1990: Part 1,2,4,7.

Edincliler. Ayse. (2008). *Utilization of Waste Tires for Geotechnical Applications as Lightweight Materials*.

Erol. G., Ali. K. E. (2009). Mechanical properties of granular rubber-sand determine by triaxial test. *2nd International Conference on New Development in Soil Mechanics and Geotechnical Engineering.*

Foose. G. J., Craig. H. B. and Boscher. P. J. (1996). Sand reinforcement with shredded waste tires. *Environmental Geotechnical report No.93-3.*

Ghazavi. Mahmoud. And Sakhi. Masoud. Amel. (2005). Influence of Optimized Tire Shreds on Shear Strength Parameters of Sand. *International Journal of Geomechanics*.

Gotteland. P., Lambert. S., Balachowski. L. (2005). Strength characteristics of tyre chips-sand mixtures. *Studia Geotechnica et Mechanica*. 27 (1-2), 55-66.

Hazarika. H., Hyodo. M. and Yasuhara. K. (2010). Tire chips mixture as preventative measure against liquefaction. *Geoshanghai 2010 International Conference*.

Head.K.H. (2009). *Manual of Soil Laboratory Testing Volume 1: Soil Classification and Compaction Tests*, (3rd ed.) Whittles Publishing.

Head.K.H. (2009). *Manual of Soil Laboratory Testing Volume 2: Permeability Shear Strength and Compressibility tests*, (3rd ed.) Whittles Publishing.

Head.K.H. (2009). *Manual of Soil Laboratory Testing Volume 3: Effective stress tests*, (3rd ed.) Whittles Publishing.

Lee. K. M. (2003). Lightly cemented scrap tire chips as LGM for construction of earth structure. *MAStec 2003-Material Division of the Hong Kong Institure of Engineers*.

Lee. J. H., Salgado. R., Bernal. and Lovell. C. W. (1999). Shredded tires and rubber sand as lightweight backfill. *Journal of geotechnical and geoenvironment engineering*.

Mavroulidou. M., Etan. O. and Suntharalingam. M. (2009). Mechanical properties of granulated tyre rubber-sand mixture. *11th International Conference on Environmental Science and Technology.*

Muni Budhu. (2007). *Soil Mechanics and Foundation*, (2nd ed.) John Wiley & Sons.

Reddy. Krishna. R (2001) Properties of different size scrap tire shreds: Implications on using as drainage material in landfill cover systems. *The Seventeenth*