DETERMINATION OF PLASTIC LIMIT OF SOIL USING MODIFIED CONE PENETRATION METHOD

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A master's project submitted in fulfillment of the requirement for award of the degree of Master of Engineering (Civil-Geotechnic)

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NOVEMBER 2005

Dedicated to my beloved mother, father, family and...especially for my wife

ACKNOWLEDGEMENT

First of all, in humble way I wish to give all the Praise to Allah, the Almighty God for with His mercy has given me the strength, blessing and time to complete this work.

I am deeply indebted to Assoc. Prof. Dr. Khairul Anuar Kassim, my supervisors, his patience, supervision, encouragement and thoughtful guidance towards the completion of this thesis. Without his continued support and interest, this thesis would not have been the same as presented here.

I am also wish to express special appreciation to all staff of geotechnical laboratory for their guidance, advices and motivation especially to En Zulkiflie and Pak Samad.

Last but not list, I would like to acknowledge to my beloved mother, Mrs. Sharipah bte Wan Ismail, my father, Mr A Rashid bin Omar, and my family whose, patience and love enabled me to complete this research. And especially grateful for someone who very supportive and caring to me, my lovely wife Suhaila Bte Borhamdin, thank you so much.

ABSTRACT

Plastic limit is an important property of fine-grained soils. The standard thread-rolling method for determining the plastic limit has long been criticized for requiring considerable judgments from the operator. Therefore, this study is conducted to introduce a new method on determining the plastic limit value using the cone penetration method similar to the liquid limit test but with slight modification on the size and the weight of cone. This is to overcome the inconsistence in the standard thread-rolling method to achieve the plastic limit. Three different types of cone with different sizes and weight have been fabricated and tested to determine the plastic limit values. These values were compared with the standard thread-rolling method. Cone (i) is based on the current study with the cone weight of 101.47g and cone angle of 20^{o}. Cone (ii) is proposed by Wood and Wroth (1978) with the cone weight of 240g and cone angle of 30^{o}. Cone (iii) proposed by Tao-Wei Feng (2004) is based on the weight of cone of 80g and angle of cone of 30^{o} with small container; 20-mm diameter and 20-mm deep. Four soil samples from different part of Johor with Plasticity Index (PI) values ranging from 15 to 30 were tested. The soils are Kota Tinggi black clay, Kulai white clay, Kota Tinggi red clay and kaolin clay. Results indicated that, the regression analyses between plastic limit values obtained from thread rolling method and all the cone penetration methods were ranged from 0.9163 to 0.9943. This indicates that all the cones are feasible of performing the plastic limit test. However cone (i) gives the best correlation with the standard thread rolling method compared to other cone methods.

ABSTRAK

Had plastik merupakan sifat yang penting bagi tanah butiran halus. Ujian had plastik piawai yang digunakan dalam menentukan had plastik tanah telah mendapat kritikan kerana kesukaran operator dalam menentukan had plastik tanah. Oleh demikian, kajian ini dijalankan untuk memperkenalkan kaedah baru dalam menentukan nilai had plastik dengan menggunakan kaedah penusukan kon yang seakan-akan sama dengan ujian had cecair tetapi dengan sedikit pengubahsuaian pada saiz dan berat kon. Ini bertujuan untuk mengatasi ketidakkonsistenan dalam kaedah piawai Tiga jenis kon yang berbeza dari segi saiz dan berat telah direka dan digunakan untuk menentukan nilai had plastik. Nilai had plastik tersebut akan dibandingkan dengan kaedah piawai. Kon (i) merupakan kon utama bagi kajian ini, dengan berat bagi kon 101.47 g dan sudut bagi kon 20^{o}. Kon (ii) merupakan kon yang diperkenalkan oleh Wood dan Wroth (1978) dengan berat bagi kon 240 g dan sudut bagi kon 30^{o}. Kon (iii) merupakakan kon yang diperkenalkan oleh Tao-Wei Feng (2004) dengan berat bagi kon 80 g dan sudut bagi kon 30^{o} dengan menggunakan bekas yang kecil; diameter 20 mm dan kedalaman 20 mm. Empat jenis sampel tanah dari pelbagai kawasan di Johor dengan nilai Indeks Keplastikan (PI) dalam lingkungan 15 hingga 30 telah digunakan dalam ujikaji ini. Tanah-tanah tersebut adalah tanah liat hitam Kota Tinggi, tanah liat putih Kulai, tanah liat merah Kota Tinggi dan tanah liat kaolin. Berdasarkan daripada analisa, didapati nilai regerasi antara nilai had plastik yang diperoleh dari ujian piawai had plastik dengan ujian penusukan adalah dalam lingkungan 0.9163 hingga 0.9943. Ini bermakna, semua ujian penusukan sesuai digunakan bagi menentukan had plastik dengan kon (i) memberikan hubungkait yang terbaik dengan kaedah piawai berbanding dengan kon yang lain.

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CHAPTER 1

INTRODUCTION

1.0 Introduction

The soil can be remolded in the presence of some moisture without crumbling, when clay minerals are represented in fine-grained soil. This cohesive nature cause by the adsorbed water surrounding the clay particles causes. In the early 1900s, a Swedish scientist named Atterberg developed a method to describe the consistency of fine-grained soils with varying moisture contents. Soil behaves more like a solid at very low moisture content and may be flow like a liquid when the moisture content is very high. Therefore, the soil behavior is depending on the moisture content level. Hence, on an arbitrary basis, depending on the moisture content, the behavior of soil can be divided into four basic states. They are solid, semisolid, plastic and liquid.

The moisture content, in percent, at which the transition from solid to semisolid state takes place, is defined as the shrinkage limit. The plastic limit he moisture content at the point of transition from semisolid to plastic state is, and from plastic to liquid state is the liquid limit. These are also known as Atterberg limits. The plastic limit defined as the moisture content in percent, at which the soil crumbles, when rolled into threads of 3 mm in diameter. The plastic limit is the lower of the stage of soil. The plastic limit test is simple and is performed by repeated rolling of an ellipsoidal-size soil mass by hand on a ground glass plate. However, there have been criticisms about this test since the operator is required to judge the state of crumbling and a 3-mm diameter of the thread. (Tao-Wei Feng 2004)

The purpose of this study is to introducing an alternative method on determines the plastic limit value of soil and to overcome the inconsistence result in determine plastic limit by using standard method that stated in BS 1377 (Thread Rolling Method).

1.1 Objectives

There are several objectives for this project:

i) To establish the fundamental criteria for plastic limit using cone penetration method.
ii) To get the similarity between the standard method on the determination of plastic limit with the new Modified Cone Penetration Method.
iii) To compare the plastic limit obtain using cone penetration method with the pervious study.

1.2 Project Background

The plastic limit is an important property of fine-grained soils. According to Tao-Wei Feng (2004), the standard thread-rolling method for determining the plastic limit has long been criticized for requiring considerable judgements from the operator. The standard thread-rolling method is not an easier way to judge the state of crumbling and a 3 mm diameter of the thread accurately for determine the value of Plastic Limit. Despite that, the standard method needs a lot of time and our conscientious.

Therefore, in developing a less operator-dependent method for determining the plastic limit, it is noticed that the fall-cone liquid limit test is rather simple and require very simple and requires very little judgement from the operator. It would be ideal if the plastic limit could be determined by using fall cone apparatus.

1.3 Scope of Study

- 4 types of soil will be tested to determine the impressive of modified cone penetration method.
- Plasticity Index (PI) value for the soil range from 10 to 40.
- For this project, 4 tests will be conducted:

i. Soil Particle Size Distribution Test

ii. Liquid Limit Test (Standard Cone Penetration Test)

iii. Plastic Limit Test (Standard Test)

iv. Plastic Limit Test (Modified Cone Penetration Test)

6.2 Recommendation

Further recommendation study stated as below:

- Use more soil samples and focus only for one cone to ensure the validity of the method.
- Conduct a test on undrained shear strength of soil to obtain the average value of it for comparing the value that been proposes by Wood and Wroth 1975 (1.7 kN/m^2 for liquid limit).

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