CALIFORNIA BEARING RATIO CORRELATION WITH SOIL INDEX PROPERTIES

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To my beloved parents and sisters

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ABSTRACT

California Bearing Ratio (CBR) is a commonly used indirect method to assess the stiffness modulus and shear strength of subgrade in pavement design works, however; civil engineers always encounter difficulties in obtaining representative CBR value for design of pavement. Over the years, many correlations had been proposed by various researchers in which the soil index properties were used to develop these correlations. A study was carried out to find the correlation between CBR values with soil index properties that best suit the type of soils in Malaysia. Analyses were carried out based on the published correlations and soil data obtained from two highway project sites. Based on the results, it is observed that the current published correlations are not suitable to be used in Malaysia. In addition, no typical range could be found based on the soil index properties. A correlation had been proposed in the study to predict the CBR values at top face of the soil sample for fine-grained soil based on the soil data collated. These correlations were developed based on the maximum dry density and optimum moisture content.

ABSTRAK

Nisbah Galas California (CBR) merupakan satu kaedah tidak langsung untuk mengukur modulus kekerasan and kekuatan rich tanah bagi kerja-kerja rekabentuk jalan raya berturap, tetapi; jurutera awam sentiasa menghadapi masalah untuk mendapatkan nilai CBR yang boleh digunakan untuk rekabentuk. Tahun-tahun yang lepas, banyak pertalian telah dicadangkan oleh banyak penyelidik dimana ciri-ciri indeks tanah telah digunakan untuk mendapatkan pertalian ini. Satu penyelidikan telah dijalankan untuk mendapatkan pertalian antara nilai CBR dengan ciri-ciri indeks tanah yang boleh digunakan untuk jenis tanah di Malaysia. Analisis berpandukan pertalian yang telah diterbitkan dan data tanah yang didapatkan dari dua projek lebuhraya. Keputusan analisis menunjukkan pertalian yang telah diterbitkan ini tidak sesuai digunakan di Malaysia. Tambahan lagi, tipikal had nilai CBR tidak diperolehi berpandukan ciri-ciri indeks tanah. Satu pertalian baru telah dicadangkan dalam penyelidikan ini untuk menganggar nilai CBR di muka atas sampel tanah jelekit berpandukan data tanah yang dikumpul. Pertalian ini diterbitkan berpandukan kepada ketumpatan kering maksimum dan kandungan lembapan optimum tanah.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

A	-	Percentage passing 2.4 mm BS sieve
CBR	-	California Bearing Ratio
$CBR_{A\&G}$	-	CBR value predicted by the Agarwal and Ghanekar's correlation
CBR_{TOP}	-	CBR value at top face of soil sample
$CBR_{TOP(\pm 3\%)}$	-	Minimum CBR_{TOP} within the range of ±3% of OMC
CBR_{BOTTOM}	-	CBR value at bottom face of soil sample
$CBR_{BOTTOM(\pm 3\%)}$	-	Minimum CBR_{BOTTOM} within the range of ±3% of OMC
DCP	-	Dynamic Cone Penetrometer
D_{60}	-	Diameter at 60% passing from grain size distribution (mm)
LL	-	Liquid Limit
MDD	-	Maximum Dry Density
OMC	-	Optimum Moisture Content
PI	-	Plasticity Index
w	-	Percentage passing No.200 U.S. sieve (in decimal)

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

California Bearing Ratio (CBR) is frequently used index test value for civil engineer particularly those in pavement construction to assess the stiffness modulus and shear strength of subgrade. It is actually an indirect measure which represents comparison of the strength of subgrade material to the strength of standard crushed rock quoted in percentage values. The method was originally developed at California Division of Highways in 1930s to provide an assessment of the relative stability of fine crushed rock base material.

California Bearing Ratio is not something new to civil engineers in Malaysia especially for those involved in road and airport pavement works. Usually, the CBR values are used by pavement engineers to design the thickness of pavement that will be laid on top of the subgrade. Subgrade that has lower CBR value will have thicker pavement compared with the subgrade that has higher CBR value. In other words, the design of pavement is very much dependent on the CBR value of subgrade. Different soil types give different values of CBR although it is compacted at the same amount of energy and rate of penetration.

Conventionally, CBR value can be measured directly in the laboratory test in accordance with BS1377 on soil sample acquired from site. The soil sample will be compacted as required in a standard mould and then a plunger is made to penetrate the soil at a specified penetration rate. Load – deflection curve plotted from the result of the penetration will be compared with that obtained from the standard crush rock.

Apart from CBR test carried out in laboratory, engineer frequently conducts indirect measurement of CBR value at project site. Dynamic Cone Penetrometer (DCP) is a popular in-situ test method commonly used to estimate the in-situ CBR value. However, the CBR value obtained from DCP test shall not be relied upon for pavement design as it may represent unsoaked CBR value rather than soaked CBR value which is required for design. Therefore, engineer is advised not to use the CBR value obtained from DCP test for pavement design but only as a comparison and estimation of CBR values that can be achieved by the subgrade.

DCP test although does not give exact soaked CBR value for design, it is always proposed by engineers for subgrade assessment because it is an easy, cheap and fast method compared with laboratory test. While laboratory test takes at least four (4) days to measure the CBR value for each soil sample, DCP tests can give immediate results of CBR values at various locations just in one day. Nevertheless, it is still a good engineering practice that DCP test is being carried in a project as a supplement to laboratory testing when assessing the shear strength and stiffness modulus of subgrade.

A more reliable method of predicting CBR value of subgrade shall be explored so that the engineers will have more options and confidence in obtaining a representative soaked CBR value for pavement design.

One of the methods is by developing a correlation between CBR values with soil index properties. There are few correlations that have been published by many researchers since 1960s. In Malaysia, practising engineers seldom use these correlations as it may be due to its unproven results on the Malaysia soils. Although there are some researches had been carried out by our local universities, no extensive data have been collated from a number of projects in Malaysia for verification purposes.

1.2 Problem Statement

Civil engineers always encounter difficulties in obtaining representative CBR value for design of pavement. Inadequate soil investigation data due to budget constraint and poor planning of soil investigation works are regularly happened here in Malaysia. In addition, laboratory CBR test required a relatively large soil sample and is time consuming. Furthermore, the results sometimes are not accurate due to the poor quality of handling and laboratory testing on the soil samples. Thus, identification of factors that governs the CBR value such as index properties and classification of the soil can be used as a base of the judgement on the validity of the CBR values obtained in the field.

1.3 Aim and Objectives of Study

The aim of the study is to find correlation between CBR values with soil index properties that best suit the type of soils in Malaysia. In order to achieve this aim, three objectives have been identified for the study:

1. To evaluate published correlation for CBR value and the index properties of soil based on collated data acquired from a number of projects in Malaysia.

2. To tabulate the CBR values obtained from collated soil samples and propose a typical range of CBR values samples based on the soil index properties.

3. To obtain a correlation between CBR values with soil index properties that is best suited for the type of soils in Malaysia.

1.4 Scope of Study

The study covers only the Malaysian practices in predicting CBR values for pavement design. Site and laboratory tests will not be carried out thus all the soil information and test results will be obtained from soil investigation contractors and commercial laboratories.

The correlations to be reviewed and analysed in this study will be limited to published correlations of CBR values with soil index properties that are generally acceptable by engineers worldwide.

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