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Establishment of Correlations for Prediction of CBR Using Non-Destructive Testing Equipment

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Abstract

Soil compaction is one among the foremost critical components within the construction of roads, airfields, embankments, and foundations. The durability and stability of a structure are related to achieving a proper soil compaction. Consequently, the compaction control of different soils used in the construction of highways and embankments is needed for enhancing their engineering properties. The current methods for assessing the standard control for construction of highways is predicted on determining the sector unit weight measurements and comparing that to the utmost measure weight decided in the standard or modified Proctor tests that are conducted in the laboratory. The field dry unit weight measurement is determined using either destructive tests, which include the sand cone, the rubber balloon, and the core cutter methods; or other non-destructive tests such as the nuclear density gauge.

The purpose of soil compaction is to improve its engineering properties not only their dry unit weight and moisture content (Holtz and Kovacs, 1981). Pinard (1998) stated that quality control specifications suffer from a number of problems since the used unit weight criteria do not reflect the engineering properties of soils in roadway conditions. eming (1998) also reached to similar conclusions.

***Key Words*:** Bituminous Concrete (BC), NDT test, soil core cutter methods.

INTRODUCTION

The purpose of soil compaction is to improve its engineering properties not only their dry unit weight and moisture content (Holtz and Kovacs, 1981). Pinard (1998) internal **control** specifications suffer from variety of problems since the used unit weight criteria do not reflect the engineering properties of soils in roadway conditions. Fleming (1998) also reached to similar conclusions. In addition, the key functional property of a base and sub base layers is their stiffness modulus, which is taken into account to be a measure of the standard of support which they supply to the overlaying asphalt or concrete layers (Fleming et al. 2001). Finally, the planning method of pavements is predicated on engineering parameters of materials such as their stiffness and /or strength, which results in a missing link between the design process and construction quality control.

OBJECTIVES OF THE STUDY

The main objective of this thesis is to assess the potential use of the Geogauge as Quality control/Quality assurance device for testing sub grades, base courses and compacted soil layers. To achieve this objective field studies are conducted at forty selected locations and Laboratory studies to determine depth of influence of Geogauge and effect of cure time on clay cement. Secondary objective was to Predict Resilient modulus and CBR Prediction Models for Base and Sub grade Pavement Layers from in Situ Device Geogauge Test Results.

The present study is taken up with the following objectives

1. To evaluate the feasibility of using Geogauge and DCP devices to measure in-situ stiffness modulus of constructed highway layers and embankments.
2. To determine the depth of influence zone of Geogauge
3. Correlating Geogauge with Dynamic Cone Penetrometer.

REVIEW OF LITERATURE

This chapter presents a review of test devices Geogauge and Dynamic cone Penetrometer. It also includes existing correlations for soil measurement acquired by these test devices.

The Geogauge may be a hand portable device capable of performing simple and robust measurements of the in-situ stiffness of soils. It is manufactured by the Humboldt Manufacturing Company. As advertised by the manufacturer, the Geogauge provides precise means of measuring the stiffness and elastic modulus of the compacted sub grade, sub base and base course layers in pavement and other earthen constructions.

Geogauge has the potential to change the present methods of QC/QA for compacted soils supported density criterion, which is additionally the most reason for developing the device. The Federal Highway Administration (FHWA) supervised a research effort to develop a device, which is faster, cheaper, safer and more accurate compaction testing device.

EXPERIMENTAL INVESTIGATIONS

Introduction

The intent of this chapter is to explain the procedure which is going to adopt in this present study. A flow chart involving proposed methodology is shown in figure 3.1. Six steps are identified and each is discussed in the following paragraphs.

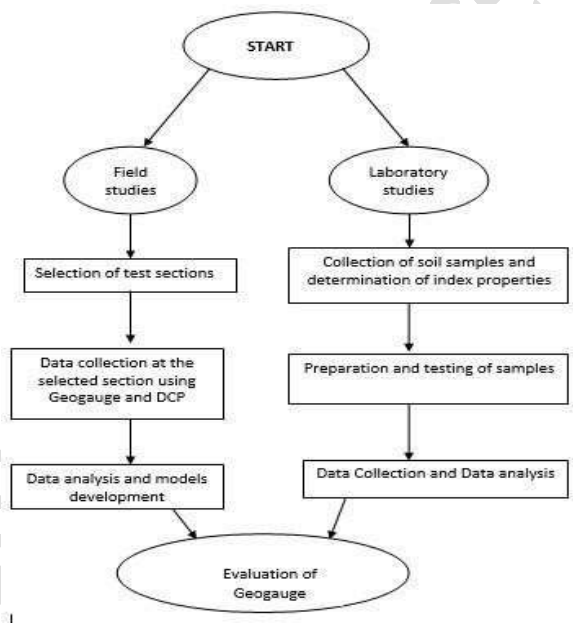

Figure 3.1: Flow Chart showing study methodology

DATA COLLECTION

Data collected at the selected sites using Geogauge and Dynamic cone Penetrometer. At each location collect the Geogauge readings (Stiffness and young's modulus) thrice and DCP readings (PR) once. The test sequence is also important since DCP test is inimally invasive and it creates a hole at the tested section. Therefore the test sequence was selected as follows

- Geogauge
- DCP

DATA ANALYSIS AND MODEL DEVELOPMENT

In this stage the collected data will be analyzed using MS-EXCEL. Models are developed for stiffness and young's modulus in terms of penetration rate. To know how exactly stiffness, young's modules varies with penetration rate different models (Linear, Logarithmic, polynomial, power and Exponential) were formulated with their coefficient of variation. Resilient modulus and CBR Predication models for sub grade and Base layer from insitu device Geogauge were developed. For this Resilient modulus and CBR values are back calculated from DCP- PR correlation equations.

LABORATORY STUDIES:

COLLECTION OF SOIL SAMPLES AND DETERMINATION OF INDEX PROPERTIES

COLLECTION OF SOIL SAMPLES

The soils selected in the study are commonly used for the construction of sub grade and embankments. Three types of sub grade soil (BC soil, sand and Murom) were selected for testing in the present study.

DETERMINATION OF INDEX PROPERTIES

Different laboratory experiments are proposed to be conducted on the entire soil sample to find out the index properties of soil samples. These tests include

- Liquid limit test
- Plastic limit test
- California bearing ratio test
- Standard proctors compaction test (MDD and OMC)
- Grain size distribution

a) Liquid limit test

Liquid limit test was conducted for all the samples using the Casagrande liquid limit apparatus as per the procedure laid down in the IS: 2720-Part-v, 1970.Liquid limit is the water content at which the soil has such a low shear strength it flows to close a groove of standard dimensions for a length of 12.5mmwhen jarred 25 times using the standard liquid limit device.

b) Plastic limit test

Plastic limit test for all the soil sample has been conducted after the mix passing through the IS: 425 sieve as per the specifications laid down in IS: 2720 part-v-1970. Is defined as the minimum moisture content at which a soil when rolled into a thread of 3mm diameter just begins to crumble.

c) Grain size distribution

The percentage of various sizes pf particles in a given dry sample was found by particle size analysis .This was done by Sieve analysis as per IS; 2720 part 1V (1965).Sieve meant for coarse grained soil above 0.075mm.

d) Compaction test

Compaction test was done to find out the Optimum moisture content and maximum dry density using standard proctor test. Preparation of sample for proctor compaction was done as per the IS: 4332-Part-1 (1967). This test determines the Optimum amount of water to be mixed with a soil in order to obtain maximum compaction for a given compactive

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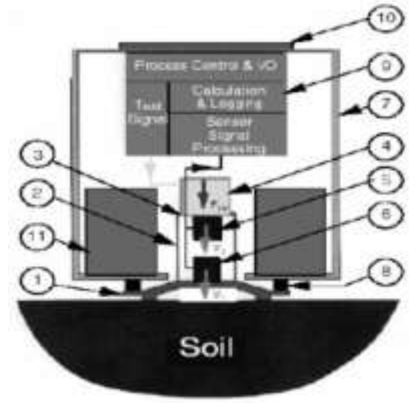
effort. This will enable the field engineer to plan field compaction of soil to a degree comparable to that obtained in the laboratory. And CBR was conducted on soil sample for soaked and unsoaked as per the IS: 2720- Part-XV.

A series of tests were performed in two test boxes located at the Centre for transportation engineering Research Lab (CTEL) for the parametric study. The parametric study objective was to determine the influence zone of the Geogauge.

EXPERIMENTAL SETUP

The two test boxes in which the tests were conducted were 330 mm (36 inch) wide, 490 mm (72 inch) long, and 450 mm (36 inch) deep. A clay layer was placed and compacted at the bottom of the first box, while a morrum layer was placed and compacted in the other box. A falling head compactor was used in this compaction.

For the tests conducted in the first box the BC soil (Soft soil) as kept bottom layer while in the second box Morrum (Stiff soil) as kept as a bottom soil. To evaluate the influence depth, the tested material was placed in the test box and compacted in 30 to 75 mm (1 to 3 inch) thick layers up to a 300 mm (12 inch). Each layer was well compacted with a standard hammer up to MDD. MDD is calculated using weight by volume relationship. Upon completion of compaction of each layer, Geogauge measurements were made at the centre of the compacted soil. It should be noted that in order to define clearly the zone of influence for the Geogauge, stiff soil was build on top of soft soil, and soft soil was build on top of stiff soil in these experiments. For example, that morrum was placed on top of the softer clay layer, while sandy soil was placed separately on top of the stiff morrum layer.



1. Rigid foot with annular ring
2. Rigid cylindrical sleeve
3. Clamped flexible plate
4. Electro-mechanical shaker
5. Upper velocity sensor
6. Lower velocity sensor
7. External case
8. Vibration isolation
9. Electronics
10. Control & display

ANALYSES OF TEST RESULT

S.NO	Model	Equation	R^2 value
1	Linear	S=-0.3871PR+16.513	0.7598
2	Logarthimic	S=-3.8814Ln(PR)+19.998	0.7515
3	Polynomial	$S=0.006PR^2-0.5799PR+17.649$	0.7777
4	Power	$S=22.857PR^{(-0.3474)}$	0.6501
5	Exponential	S=17.685e(-0.0378PR)	0.7838

AND DISCUSSIONS

The average Geogauge measurements and average DCP penetration rate for 230 mm depth at fourthy selected locations are presented in the following table.

RESULTS:

S.NO	Model	Equation	R^2 value
1	Linear	S=-0.3871PR+16.513	0.7598
2	Logarithmic	S=-3.8814Ln(PR)+19.998	0.7515
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5	Exponential	$S=17.685e^{(-0.0378PR)}$	0.7838

CONCLUSION

Based on the study the following conclusions are drawn.

- ✓ From the parametric study the depth of influence zone of Geogauge ranges between 200 and 230 mm (7.5 and 8 inch),
- ✓ Influence zone of Geogauge device depends on the stiffness of the tested layer, such that the influence depth decreases with increasing the stiffness.
- ✓ Developed Geogauge stiffness and DCP-PR models are summarized below

LIMITATIONS OF THE STUDY

- ➢ Laboratory Resilient modulus values are not determined to develop Resilient modulus Prediction models. To predict Resilient modulus models developed by chen et al(2005) was used
- ➢ Laboratory CBR values are not determined to develop CBR Prediction models. To predict CBR ,models developed by coonse(1999) was used.

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