Evaluation of Compaction Characteristics of A-7-5 Soil Using Dynamic Cone Penetrometer

Lal Chand Marwari[1], Aneel Kumar Hindu[1], Naeem Aziz Memon[1], Shankar Lal Meghwar[1] Anees Raja Siddiqui[1], Anees Ahmed Vighyo[1]

[1]*Department of Civil Engineering Mehran-UET, Jamshoro, Pakistan*

***Abstract*: The engineering properties of soil are highly variable which makes this material unpredictably complex. Also, some of its properties like maximum dry density (MDD) and optimum moisture content (OMC) are too laborious and time consuming to determine. Therefore there is always a need to develop correlations between different properties of soil so that indirect measurements of difficult properties can be made. This study aims to develop correlations between compaction characteristics (MDD & OMC) of A-7-5 soil & its dynamic cone penetration index value (DCPI). For this purpose, soils samples from different areas of Jamshoro have been collected and proportionally mixed to obtain different specimen of A-7-5 soil as per AASHTO soil classification. A number of modified proctor compaction tests and dynamic cone penetration tests have been performed on each soil sample. On the basis of test results, different correlations have been developed between maximum dry density, optimum moisture content and dynamic cone penetration values of soil. The resulting coefficients of determination suggest that the correlations obtained can be used with confidence. The developed correlations will guide the local industry for estimating the compaction characteristics of A-7-5 soil from DCP test resulting in time and resource saving**

***Keywords*: Dynamic Cone Penetrometer Index (DCPI), Compact Characteristics, Compressive Strength.**

I. INTRODUCTION

The soil is a natural material having engineering properties that are highly variable. It is always difficult for geotechnical engineers to find reliable parameters of soil because its properties vary from place to place. There are various soil properties like maximum dry density, optimum moisture content, unconfined compressive strength and resilient modulus, whose determination is time consuming, tedious and expensive [1,2]. The soil investigation for such properties may frequently cause delays in the completion of civil engineering projects. On the other hand, the Dynamic Cone Penetration test of soil is a non-destructive, cost-effective, fast and reliable technique that can be employed to determine the in-situ properties of subgrade soil [3,4]. Many researchers have developed empirical relationships between different soil properties and its Dynamic Cone Penetration value. For instance, the conventional method for determining the California bearing ratio (CBR) requires the use of costly equipment and is time-consuming [5, 6]. Alternatively one can determine the CBR value of soil in the field by using dynamic cone penetrometer if suitable correlations between soil DCPI and CBR value are developed [7,8]. Similarly, the Proctor compaction test for soil also involves laborious manual procedure with several trials before the final results could be obtained. This study aims to develop suitable correlations between DCPI and compaction characteristics of A-7-5 soil so that the compaction of parameters of such soils could be estimated easily and reliably without much effort.

II. LITERATURE RIVIEW

There has been a significant amount of studies undertaken to develop correlations between various soil properties. A lot of research has been conducted to correlate soil parameters that are harder to obtain, with soil properties that are relatively simple to find such as DCPI of soil. A number of researchers have investigated the relationship between DCPI and California bearing ratio (CBR) of soil. The summary of these studies conducted on different types of soils is presented in Table 1. Similar studies have also been conducted to correlate other soil properties of soil with its DCPI value [9,10]. However, very little work has been done to establish a reliable relationship between DCPI and compaction characteristics of soil i.e. optimum moisture content and maximum dry density.

III. METHODOLOGY

In order to undertake this study, a number of soil samples are first obtained from different locations of Jamshoro. These samples are then mixed in different proportions to obtain three different samples of A-7-5 soil as per AASHTO soil classification system. A number of modified compaction tests and dynamic cone penetration tests have been initiated on each soil sample to obtain the required soil parameters. An effort has been made to develop correlations between DCPI values of A-7-5 soil with its compaction characteristics using different types of regression techniques.

IV. RESULTS

The laboratory test results for modified compaction tests and DCP test conducted on A-7-5 soil samples are shown in Table 2. The resulting compaction curves for all three samples are also shown in Figure 1. The regression analysis has been undertaken between DCPI value and compaction characteristics (MDD & OMC). For this purpose, two separate scatter. Plots between DCPI & MDD and DCPI & OMC have been drawn as shown in Figure 2 & 3. Different regression techniques including linear, exponential, logarithmic and power equation have been generated for each relationship as shown below.

3.1 Correlations Generated between DCPI and MDD

As a result of regression analysis carried out between DCPI and MDD values of soil, following relationships have been generated along with their respective coefficients of determination (R^2).

- Linear Equation ($R^2 = 0.9643$)

$$MDD = -0.6429(DCP) + 2.5793 \quad R^2 = 0.9643$$

- Logarithmic Equation ($R^2 = 0.963$)

$$MDD = -0.677\ln(DCP) + 1.9373$$

- Exponential Equation ($R^2 = 0.9637$)

$$MDD = 2.7163e^{-0.338(DCP)}$$

- Power Equation ($R^2 = 0.9624$)

$$MDD = 1.9376(DCP)^{-0.356}$$

3.2 Correlations Generated between DCPI and OMC

Different relationships generated between DCPI and OMC of soil sample are shown below. It can be observed that the coefficients of determination (R^2) are less when compared to those obtained for the relationship between DCPI and MDD.

- Linear Equation ($R^2 = 0.498$)

$$OMC = 24(DCP) - 11.88$$

- Logarithmic Equation ($R^2 = 0.4913$)

$$OMC = 25.211\ln(DCP) + 12.132$$

- Exponential Equation ($R^2 = 0.4923$)

$$OMC = 2.1216e^{1.7522(DCP)}$$

- Power Equation ($R^2 = 0.4888$)

$$OMC = 12.211(DCP)^{1.8406}$$

IV CONCLUSION

The results of this study suggest that a reliable relationship exists ($R^2 > 0.9$) between DCPI and MDD of A-7-5 soil using different regression techniques. However, the relationship between DCPI and OMC of soil samples is weak ($R^2 < 0.55$) and cannot be reliably used to explain the variability. These conclusions have been drawn based on the values of coefficients of determination (R^2) obtained for different regression techniques as shown in the preceding section.

V. FIGURES AND TABLES

A. Tables

Table 1: Empirical Correlations between CBR & DPI Suggested by Different Researcher

Author	**Year**	**Correlation equation Developed**	**Soil type**
Kleyn	(1975)	Log(CBR)=2.62-1.27log (DCPI)	Unknown
Livneh	(1987)	Log(CBR)=2.56-1.16log (DCPI)	Granular and Cohesive
Harison	(1987)	Log(CBR)=2.55-1.14log (DCPI)	Granular and Cohesive
Liveneh et al.	(1992)	Log(CBR)=2.45-1.12log (DCPI)	Granular and Cohesive
Ese et al.	(1995)	Log(CBR)=2.44-1.07log (DCPI)	Aggregate base Course
Shongtao Dai	(2006)	Log CBR= 2.438-1.065logDCPI	Granular material
Charlie Kremer	(2006)	Log(CBR)=2.2-0.71 logDCPI$^{1.5}$	Granular material
Varghese George	(2009)	CBR=88.37(DPI)-1.08	Un soaked blended soils

Table 2: Test Results of A-7-5 Soil Samples

Soil Sample	MDD (g/cm^3)	OMC (%)	DCPI (cm/blow)
1	1.85	13.21	1.233
2	1.84	14.57	1.497
3	1.82	12.98	1.384

B. *Figures*

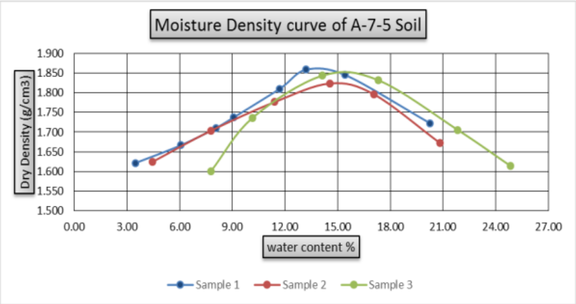

Fig.1: Modified Compaction Curves of Soil Samples

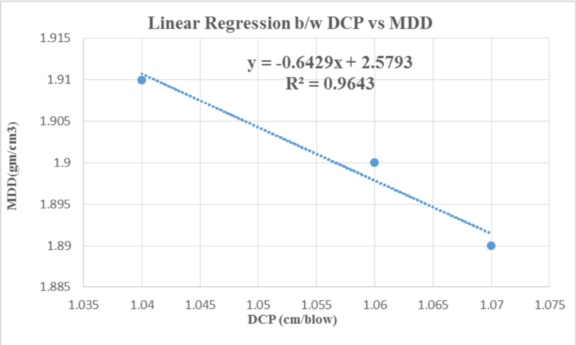

Fig. 2: Scatter Plot b/w DCPI and MDD

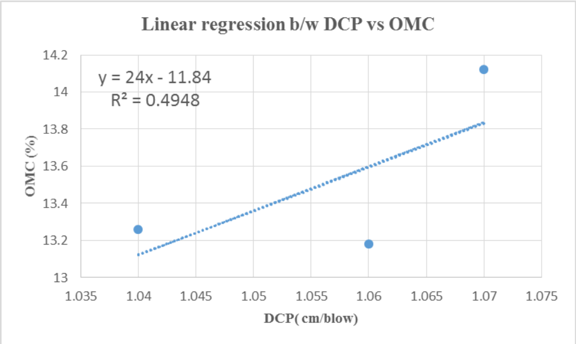

Fig.3: Scatter Plot b/w DCPI and OMC

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