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Sub-Grade Soil Assessment Using Correlation Between Dynamic Cone Penetration Indexes (DCPI) Unconfined Compressive Strength (UCS)

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Abstract: The performance of pavements depends to a large extent on the strength and stiffness of the subgrades. This paper presents the results of an extensive field and laboratory investigation of five PMGSY low volume road sections in the gujarat state. Dynamic Cone Penetration tests(DCPT), Unconfined Compressive Strength (UCS), California Bearing Ratio(CBR) tests, Maximum Dry Density(MDD) and Optimum Moisture Content (OMC) tests were performed to study the strength properties of the subgrade layer of pavements. The work described the correlations between the results obtained using the DCP and the results obtained using the UCS method for subgrade soils at various locations of PMGSY roads of gujarat state in India. A correlation between the Dynemic cone penetration index and UCS values were established. Regression models were develope same as this study to enable the prediction of UCS values based on the average penetration-rates of DCPT performed for field density.

I. INTRODUCTION

For the design of flexible pavement, the sub-grade soil strength is estimated with Unconfied Comressive Strength (UCS) test IS 2720 part:10 (IRC-37-2001). Unconfied Comressive Strength is used to evaluate the suitability of Pavement layers thickness measurement. This test can be done in the laboratory. It is an expensive and time consuming test. It is very difficult to mould the sample at desired density in the laboratory. Therefore, to overcome these problems, the other method (Dynamic Cone Penetrometer) is used in this study. This is an instrument used to evaluate strength of pavement sub grade materials. The UCS values are obtained by conventional method and with the help of Dynamic Cone Penetrometer (DCP) and both the values are correlated to find the conventional UCS value by using DCP in the field. So, with the help of this relationship, it will be easy to get information about the strength of sub grade over the length of low traffic volume road.

II. NEED OF THE PRESENT STUDY

Roads haveperformed a very vital role in meeting the strategic and developmental requirements and accelerating development. Technical progress in planning and road construction technology rapid change in the field of highway development. India in various fields of Civil Engineering including road..India owns the second largest network of roads in the world, Low traffic volume roads serve as one of the key infrastructures placedfor integrated rural development,which has become of growing for considerations of social justice,national integration and economic uplift of the rural areas.

The design of flexible pavements and recommends the Unconfied Comressive Strength (UCS) an indicator of subgrade soil strength and subbase or base thickness of pavement is consider from the Unconfied Comressive Strength UCS value of the subgrade soil with some other parameters such as traffic intensity, climatic conditions, etc. The UCS testing method is expensive, time consuming and its repeatability is low. And it is very difficult to mould the sample at the in the laboratory UCS test. Dynamic cone penetration test (DCPT) value conducted in the field can be used to estimate the UCS value provided a suitable relationship exists between UCS and DCPT value. In this study to establish a relationship between the DCPT value and the UCS.

III. OBJECTIVES OF STUDY

A. To determine the correlation between UCS and DCPT (Dynamic cone penetration test) for different soils e.g Clayey, silt and Sandy Soil.
B. To determine the validtion of DCPT with UCS of different subgrade of different test pits

IV. LITERATURE REVIEW

The DCP was developed in South Africa for evaluation of in-situ pavement strength or stiffness in the 1960s. Dr. D. J. van Vuuren designed the original DCP with a 30° cone (van Vuuren, 1969). The Transvaal Roads Department in South Africa began using the DCP to investigate road pavement in 1973 (Kleyn, 1975). Kleyn reported the relative results obtained using a 30° cone and a 60° cone. In 1982, Kleyn described another DCP design, which used a 60° cone tip, 8 kg (17.6 lb) hammer, and 575 mm (22.6 in) free fall (Kleyn, 1982). This design was then gradually adopted by countries around the globe. In 2004, the ASTM D6951-03 Standard Test Method for Use of the Dynamic Cone Penetrometer in Shallow Pavement Applications described using a DCP with this latest design (ASTM, 2004). DCP testing consists of using the DCP's free-falling hammer to strike the cone, causing the cone to penetrate the base or subgrade soil, and then measuring the penetration per blow, also called the penetration rate (PR), in mm/blow. This measurement denotes the stiffness of the tested material,with a smaller PR number indicating a stiffer material. In other words, the PR is a measurement of the penetrability of the subgrad soil.

There are two types of DCP available for field data collection. Although only the Manual DCP was used in this study.

A. Automated DCP Operation

B. Manual DCP Operation

DCP test results consist of number of blow counts versus penetration depth. Since the recorded blow counts are cumulative values, results of DCP test in general are given as incremental values defined as follows

$$DCPI = \Delta D_P / \Delta BC$$

Where;

DCPI = Dynamic Cone Petrometer Index in units of length divided by blow count;

ΔDp = penetration depth;

ΔBC = Blow Counts corresponding to penetration depth ΔDp.

form: Correlation equation form:

UCS = A + B ln(DCPI)

Where ,UCS = Unconfied Comressive Strength,

DCPI = DCP penetration resistance or penetration index in units of mm per blow

V. LABORATORY STUDIES

The following gives the step by step process of the things that are held in the laboratory:

A. 2.All the test sample for research work of project shall be performed at soil testing lab.

B. Classified soil are test for Liquid limit and plastic limit test

C. 4.All soil sample are test for standar proctor test to find optimum moisture content and maximum dry density.

D. Unconfied Comressive Strength (UCS) test perform in the lab to find strength.

E. T, M, K, B, V are denote taluka name and 1,2,3, are denote the chainage of road.

Table 1.1 : Selected PMGSY Roads Soil Lab. Test Data.

TALUKA NAME	GROUP OF SOIL	LL	PL	PI	MDD (kN/mm2)	OMC	CBR SOAKED (%)	UCS (kg/cm2)	DCPI (mm/blows)
T1	CI	40	21	19	19.1	11.6	3.8	0.45	22.57
T2	CI	45.1	21.02	24.8	18.4	12.3	3.5	0.39	23.51
T3	CI	47	24	23	18.5	12.6	3.6	0.41	22.94
M1	CH	50	25	25	18.4	13.6	4	0.3	32.52
M2	CH	52	25	27	18.2	13.3	3.6	0.32	32.08
M3	CH	47	24	23	18	13.1	3.4	0.33	30.72
K1	CI	29.81	8.1	21.71	19.4	12.6	4.6	0.55	21.76
K2	CI	29.86	17.86	12	19.5	11.2	4.5	0.54	22.86
K3	CI	29.91	7.91	22	19.4	10.8	4.6	0.57	21.6
B1	CL	28.3	20.3	8	19.8	10.2	5.9	0.68	19.1

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B2	CL	28	21	7	19.8	9.8	5.8	0.68	18.08
B3	CL	28	21	7	19.7	10.2	5.2	0.66	18.2
V1	CL	33	21	12	20.3	10	8	1.24	10.8
V2	CL	34	21	13	20.1	10.4	8.2	1.28	11.68
V3	CL	33	21	12	19.9	10	7.9	1.2	9.8

VI. FIELD STUDIES

The following gives the step by step process of the things that are held on the field:

A. First step is to survey traffic volume count.

B. Selected road measure lenght and widht and mark the point for DCPT test.

C. To excavate the pavement at the sub grade layer depth and set the instrument and blows count and penetration rate note down

D. All value of DCPI index are regression analysis of lab test data and field tested data sheet are developed

E. After the prepared graph and data consider find out the correlation between UCS and DCP

Table 1.2 DPI for all Selected PMGSY Road.

Name of Road	DCPI (mm / Blows)			
	FIRST POINT	SECOND POINT	THIRD POINT	AVERAGE
THASARA (T)	22.57	23.51	22.94	23.00666667
MAHUDHA (M)	32.52	32.08	30.72	31.77333333
KATHLAL (K)	21.76	22.86	21.6	22.07333333
BALASINOR (B)	19.1	18.08	18.2	18.46
VIRPUR (V)	10.8	11.68	9.8	10.76

A. Data Analysis

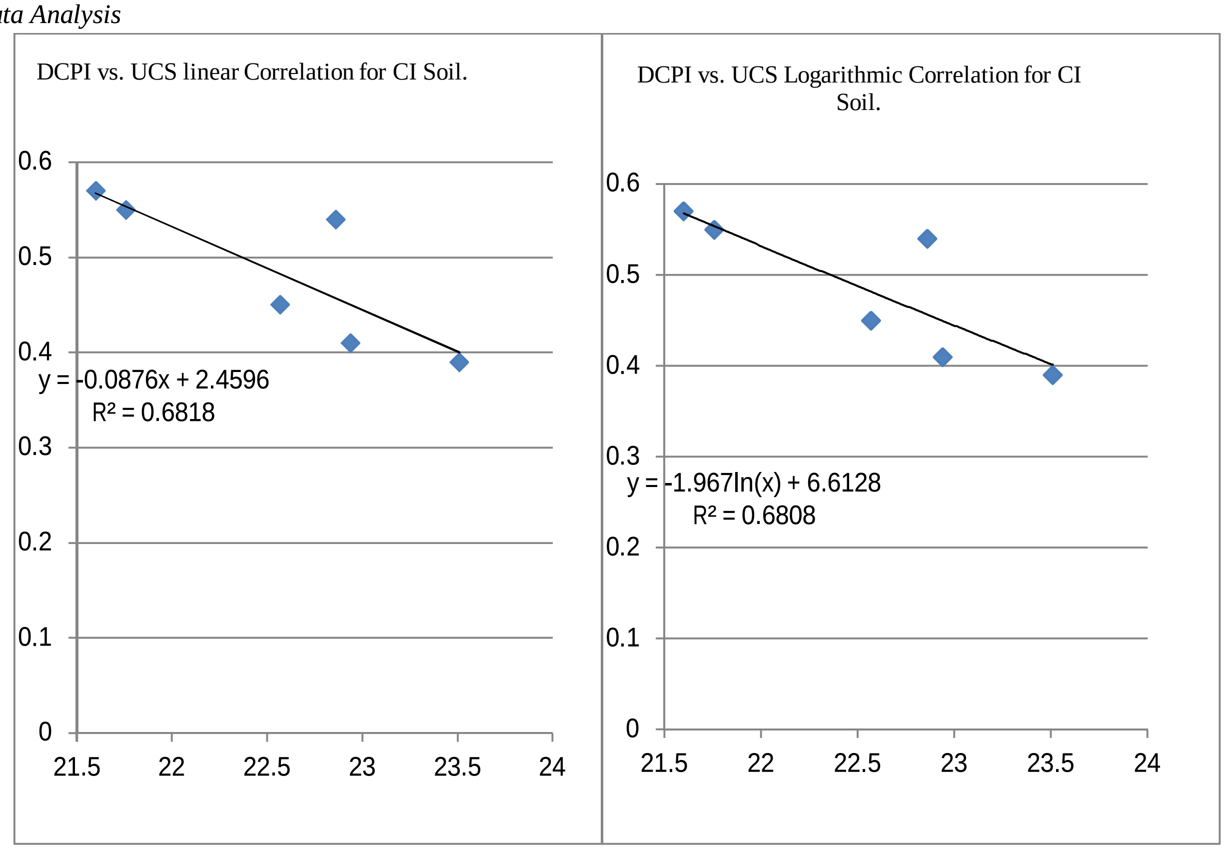

Fig. 1 : Selected PMGSY Roads DCPI vs. UCS Coreelation for CI Soil.

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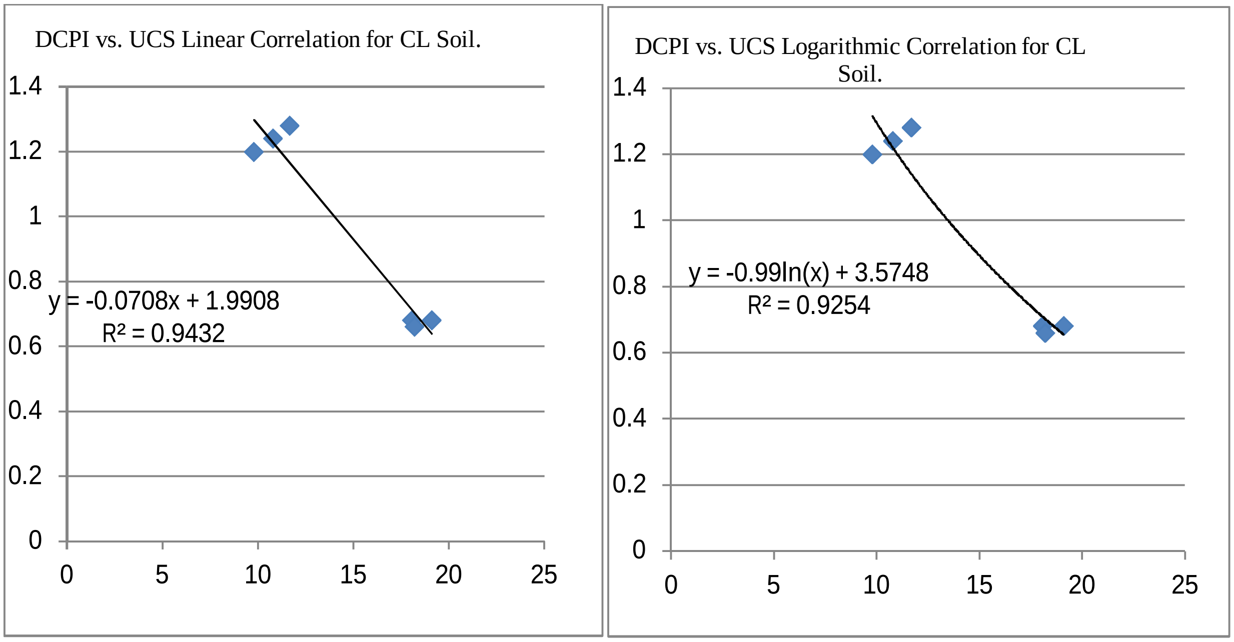

Fig. 2 Selected PMGSY Roads DCPI vs. UCS Coreelation for CL Soil

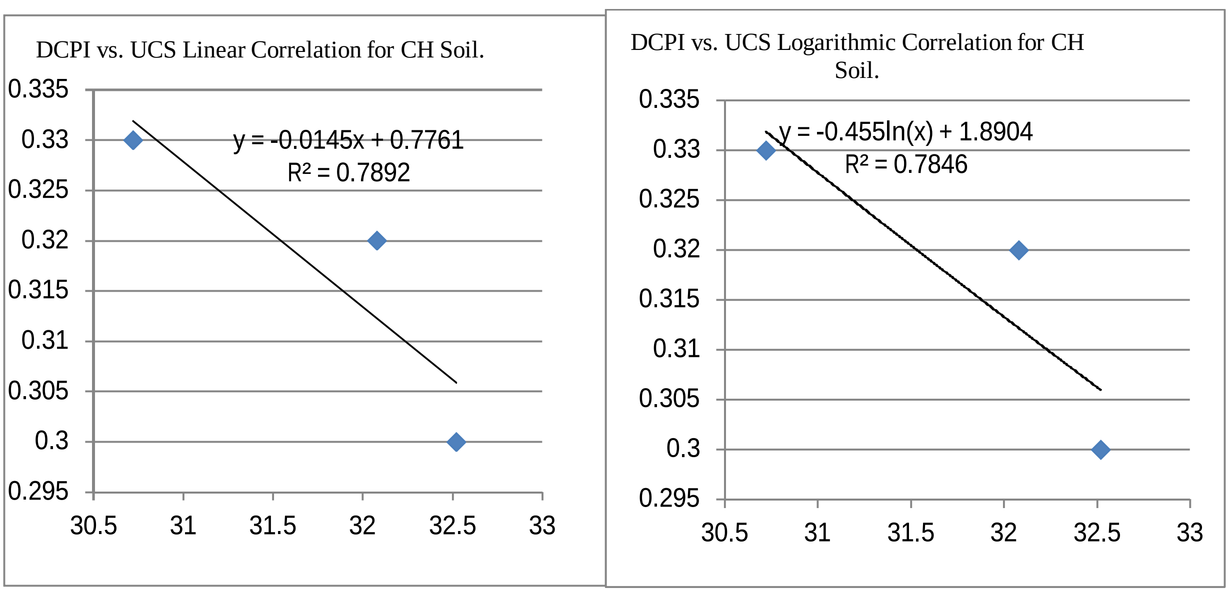

Fig. 3 : Selected Taluka PMGSY Roads DCPI vs. UCS Coreelation for CH Soil.

Table 1.3 : Regression analysis of DCPI vs. UCS Summary for All Taluka Selected PMGSY Roads (CI, CL, CH Soil).

Soil Type	Correlation	Model	Equation	R2
CI	DCPI vs. UCS	Linear	UCS = -0.087 (DCPI) + 2.459	0.681
		Logarithmic	UCS = -1.96 ln(DCPI) + 6.612	0.68
CL	DCPI vs. UCS	Linear	UCS = -0.070 (DCPI) + 1.990	0.943
		Logarithmic	UCS = -0.99 ln(DCPI) + 3.574	0.925
CH	DCPI vs. UCS	Linear	UCS = 0.014 (DCPI) + 0.776	0.789
		Logarithmic	USC = -0.145 ln(DCPI) + 1.890	0.784

VII. EXPECTED OUTCOME

The above experimental analysis was done to develope the corelations between various tests results like CBR,UCS,DCP Index of soaked condition. Table 1.3 derive various relationship and equation for relations between UCS and DCP Index .Value of R^2 are greater than 0.5 so it's derive very strong relationship among them. Non-destructive tests are becoming more popular now days for evaluation of the pavement and subgrade layers. Low cost techniques like DCP are gaining popularity due to its results and ease of operation. Analytical software now available to analyse the DCP data for evaluation and designing of low volume roads. The correlation developed under this study will be useful to estimate the UCS value from the DCPI data for low volume PMGSY roads.UCS useful to find strength of subgrade and it is usefull to consider layers thickness and different soil quality and strength.

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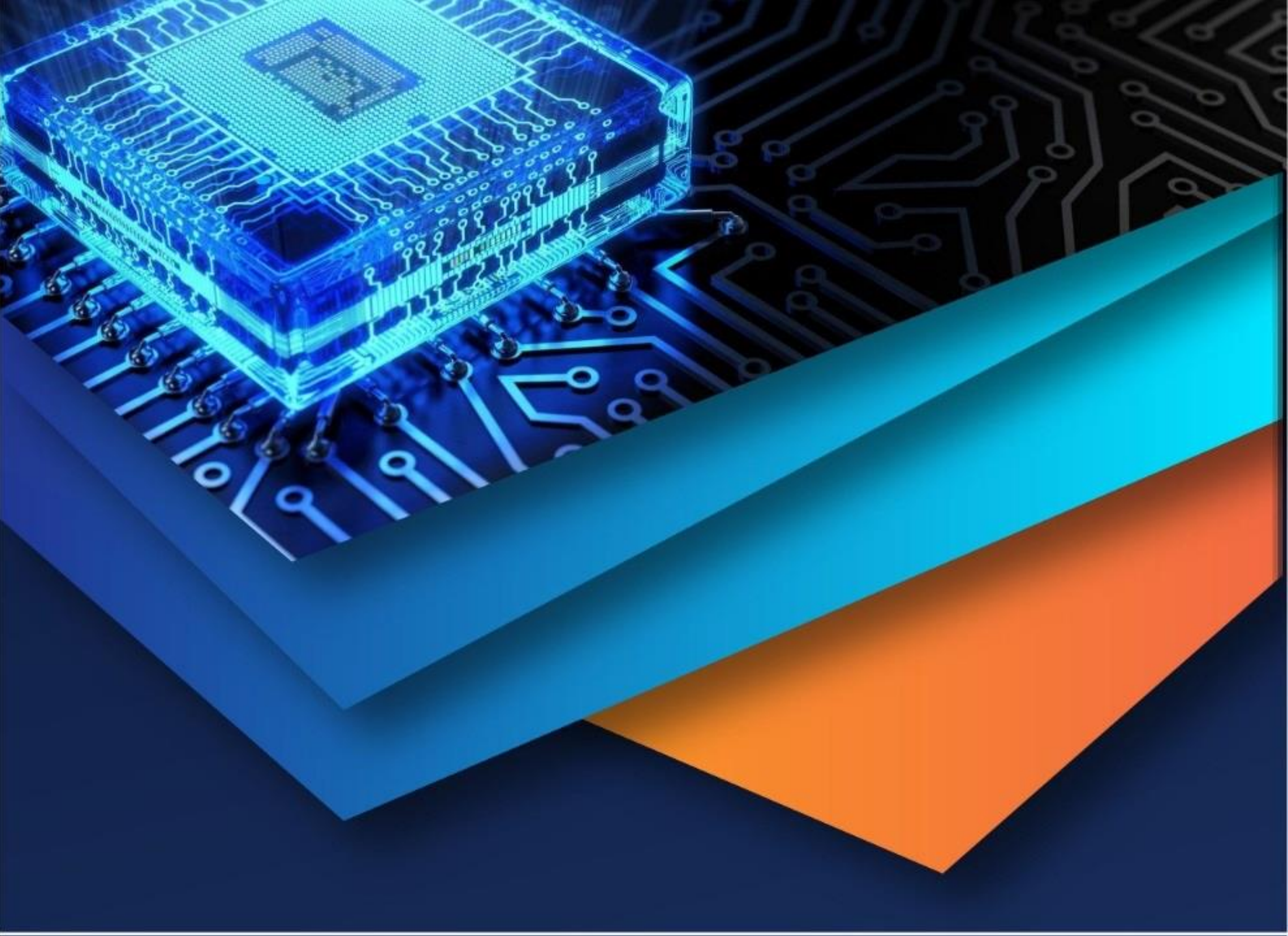

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