iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL
FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 Issue: VIII Month of publication: August 2017

DOI: http://doi.org/10.22214/ijraset.2017.8007

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue VIII, August 2017- Available at www.ijraset.com

Sub-Grade Soil Assessment Using Correlation Between Dynamic Cone Penetration Index (DCPI) California Bearing Ratio(CBR): A Case Study of PMGSY Roads

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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),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 CBR method for subgrade soils at various locations of PMGSY roads of gujarat state in India. A correlation between the Maximum Dry Density(MDD) and Optimum Moisture Content (OMC) of subgrade and DCPI penetration index and CBR values were established. Regression models were developed as part of this study to enable the prediction of CBR 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 California Bearing Ratio test IS 2720part (IRC-37-2001). In 1929, this test was developed by California Division of Highway and is used to evaluate the suitability of sub grade. This test can be done in the laboratory as well as in the field. 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 CBR 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 CBR 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 Indian Roads Congress standard deals with the design of flexible pavements and recommends the California Bearing Ratio (CBR) as an indicator of subgrade soil strength and subbase or base thickness of pavement is consider from the CBR value of the subgrade soil with some other parameters such as traffic intensity, climatic conditions, etc. The CBR 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 CBR test. Dynamic cone penetration test (DCPT) value conducted in the field can be used to estimate the CBR value provided a suitable relationship exists between CBR and DCPT value. In this study to establish a relationship between the DCPT value and the CBR.

III. OBJECTIVES OF STUDY

A. To determine the correlation between CBR (California bearing ratio) and DCPT (Dynamic cone penetration test) for different soils e.g Clayey, silt and Sandy Soil.

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

C. To determine the validtion of DCPT with UCS and CBR 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

$DCPI=\Delta D_P / \Delta BC$

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

ΔDp = penetration depth; ΔBC = Blow Counts corresponding to penetration depth ΔDp.

Salgado has mentioned that the power model (or log-log equation) has been used by different authors for the relationship between the DCPI and CBR andHarison hasconcluded that the log-log equation produces reliable results. Farshad, Ferede , and Ehsan also mentioned that most of the relationships developed between DCP and CBRare based on the best fit log-log equation having the
form:

$\log(CBR) = A + B\log(DCPI)$

Where ,CBR = California Bearing Ratio in percent

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

A and B are regression constants for the relationship

Correlation Equation	Soil type	Reference
log(CBR) = 2.81-1.32log(DCPI)	all	Harison 1989
log(CBR) = 2.20-0.71(log DCPI)1.5	all	livneh 1987
log CBR = 2.465-1.12log(DCPI)	all	U S Army corp of Engineers 1992
log(CBR) = 2.48-1.057log(DCPI)	all	TRL
log(CBR) = 2.954-1.496log(DCP	Clay unsoaked	Yitagesu 2012
log(CBR) = 2.222-0.576log(DCPI)	cohesive	TRL 1986
log(CBR) = 0.84-1.26log(DCPI)	all	IDOT 1997

V. LABORATORY STUDIES

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

A. Various types of PMGSY roads Soil sample is to be taken from the gujarat state.
B. All the test sample for research work of project shall be performed at soil testing lab.
C. Classified soil are test for Liquid limit and plastic limit test.
D. All soil sample are test for standar proctor test to find optimum moisture content and maximum dry density
E. From proctor test value California Bearing Ratio(CBR).
F. T, M, K, B, V are denote taluka name and 1,2,3, are denote the chainage of road.

Table 1.2 : Selected PMGSY Roads Soil Lab. Test Data.

TALUKA NAME	GROUP OF SOIL	LL	PL	PI	MDD (kN/mm2)	OMC	CBR SOAKED (%)	DCPI (mm/blows)
T1	CI	40	21	19	19.1	11.6	3.8	22.57
T2	CI	45.1	21.02	24.8	18.4	12.3	3.5	23.51
T3	CI	47	24	23	18.5	12.6	3.6	22.94
M1	CH	50	25	25	18.4	13.6	4	32.52
M2	CH	52	25	27	18.2	13.3	3.6	32.08
M3	CH	47	24	23	18	13.1	3.4	30.72
K1	CI	29.81	8.1	21.71	19.4	12.6	4.6	21.76
K2	CI	29.86	17.86	12	19.5	11.2	4.5	22.86
K3	CI	29.91	7.91	22	19.4	10.8	4.6	21.6
B1	CL	28.3	20.3	8	19.8	10.2	5.9	19.1
B2	CL	28	21	7	19.8	9.8	5.8	18.08
B3	CL	28	21	7	19.7	10.2	5.2	18.2
V1	CL	33	21	12	20.3	10	8	10.8
V2	CL	34	21	13	20.1	10.4	8.2	11.68
V3	CL	33	21	12	19.9	10	7.9	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 CBR and DCP.

Table 1.2 : AADT of all Selected PMGSY Road.

Description	Thasara	Mahudha	Kathlal	Balasinor	Virpur
Total motorised vehicle	149	163	151	148	153
Total non-motorised vehicle	67	69	45	55	64
Average annual daily traffic (AADT)	216	232	196	203	217

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Table 1.3 DCPI 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	23.006
MAHUDHA (M)	32.52	32.08	30.72	31.773
KATHLAL (K)	21.76	22.86	21.6	22.073
BALASINOR (B)	19.1	18.08	18.2	18.46
VIRPUR (V)	10.8	11.68	9.8	10.76

VII. DATA ANALYSIS

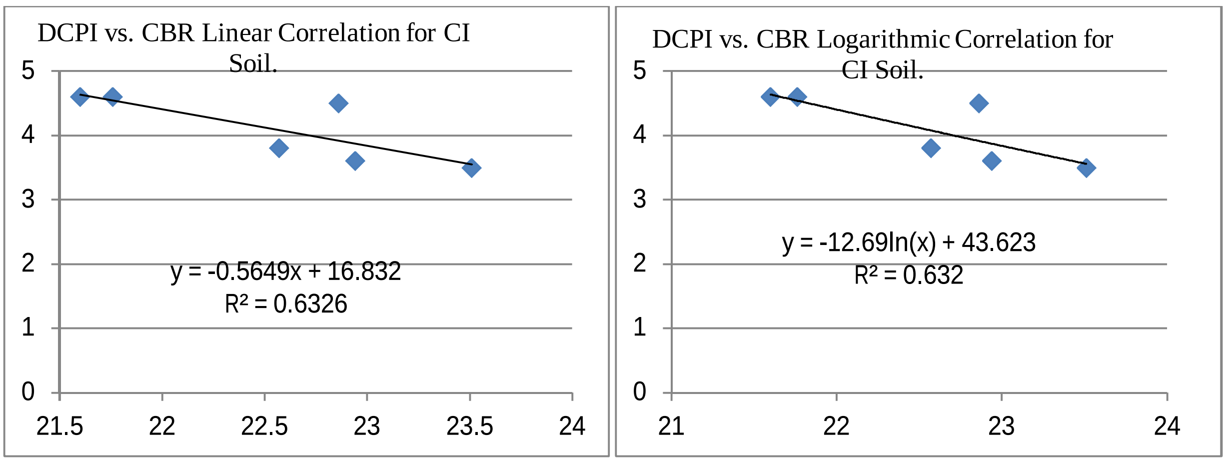

Fig. 1 : Selected PMGSY Roads DCPI vs. CBR Coreelation for CI Soil.

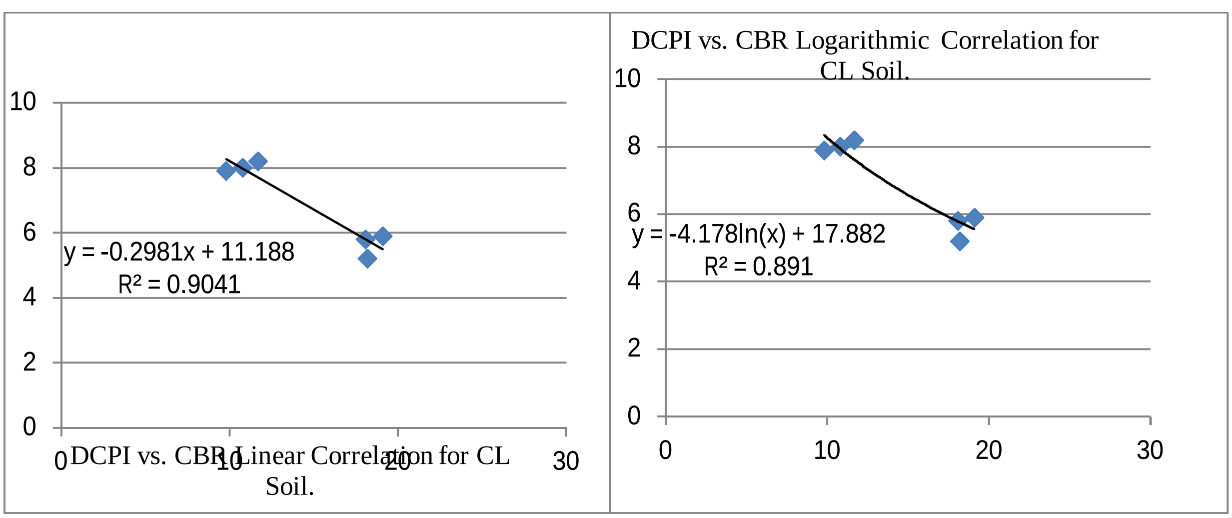

Fig. 2 Selected PMGSY Roads DCPI vs. CBR Coreelation for CL Soil.

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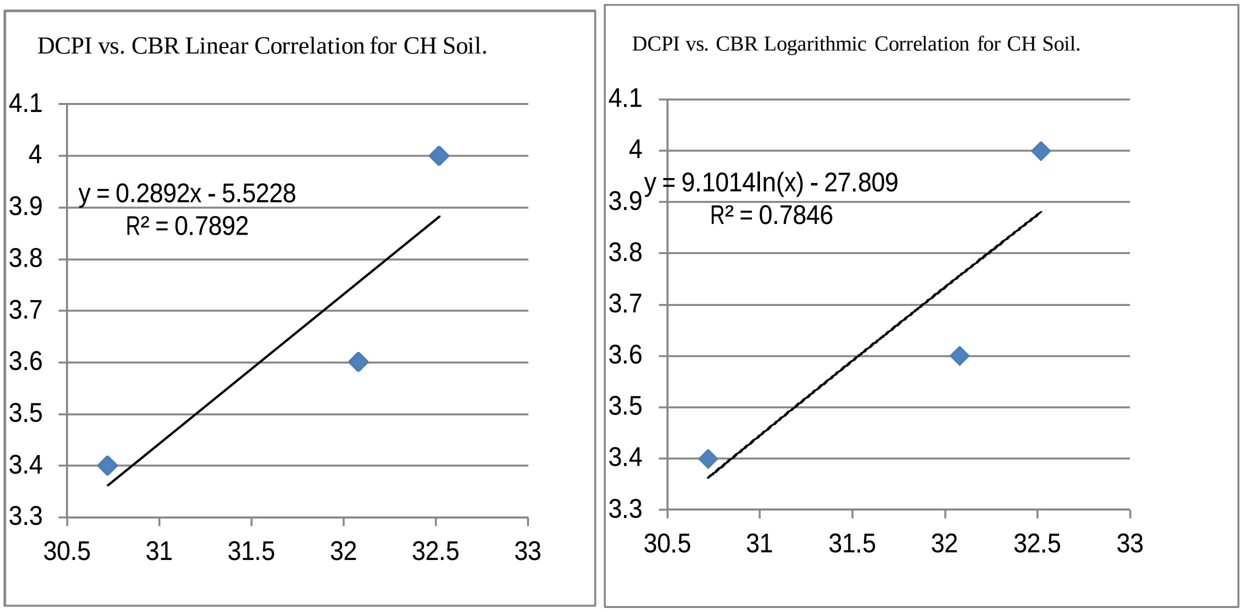

Fig. 3 : Selected Taluka PMGSY Roads DCPI vs. CBR Coreelation for CH Soil.

Table 1.4 : Regression analysis of DCPI vs. CBR Smmary for All Taluka Selected PMGSY Roads (CI, CL, CH Soil).

Soil Type	Correlation	Model	Equation	R2
CI	DCPI vs. CBR	Linear	CBR = -0.564 (DCPI) + 16.83	0.632
		Logarithmic	CBR = -12.6 ln(DCPI) + 43.62	0.632
CL	DCPI vs. CBR	Linear	CBR = -0.298 (DCPI) + 11.18	0.904
		Logarithmic	CBR = -4.17 ln(DCPI) + 17.88	0.891
CH	DCPI vs. CBR	Linear	CBR = 0.289 (DCPI) - 5.522	0.789
		Logarithmic	CBR = 9.101 ln(DCPI) - 27.80	0.784

VIII. EXPECTED OUTCOME

The above experimental analysis was done to develope the corelations between various tests results like CBR,UCS,DCP Index of soaked condition. In table 1.4 describe the linear and logarithmic correlation between DCPI and CBR and from this research get equation for correlationship. Value of R^2 are greater than 0.5 so it's derive very strong relationship. 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. An attempt to develop a correlation betweenDCP Index, CBR values. Indian Roads Congress uses the CBR based method for design of low volume roads in India. The correlation developed under this study will be useful to estimate the CBR value from the DCPI data for low volume PMGSY roads.

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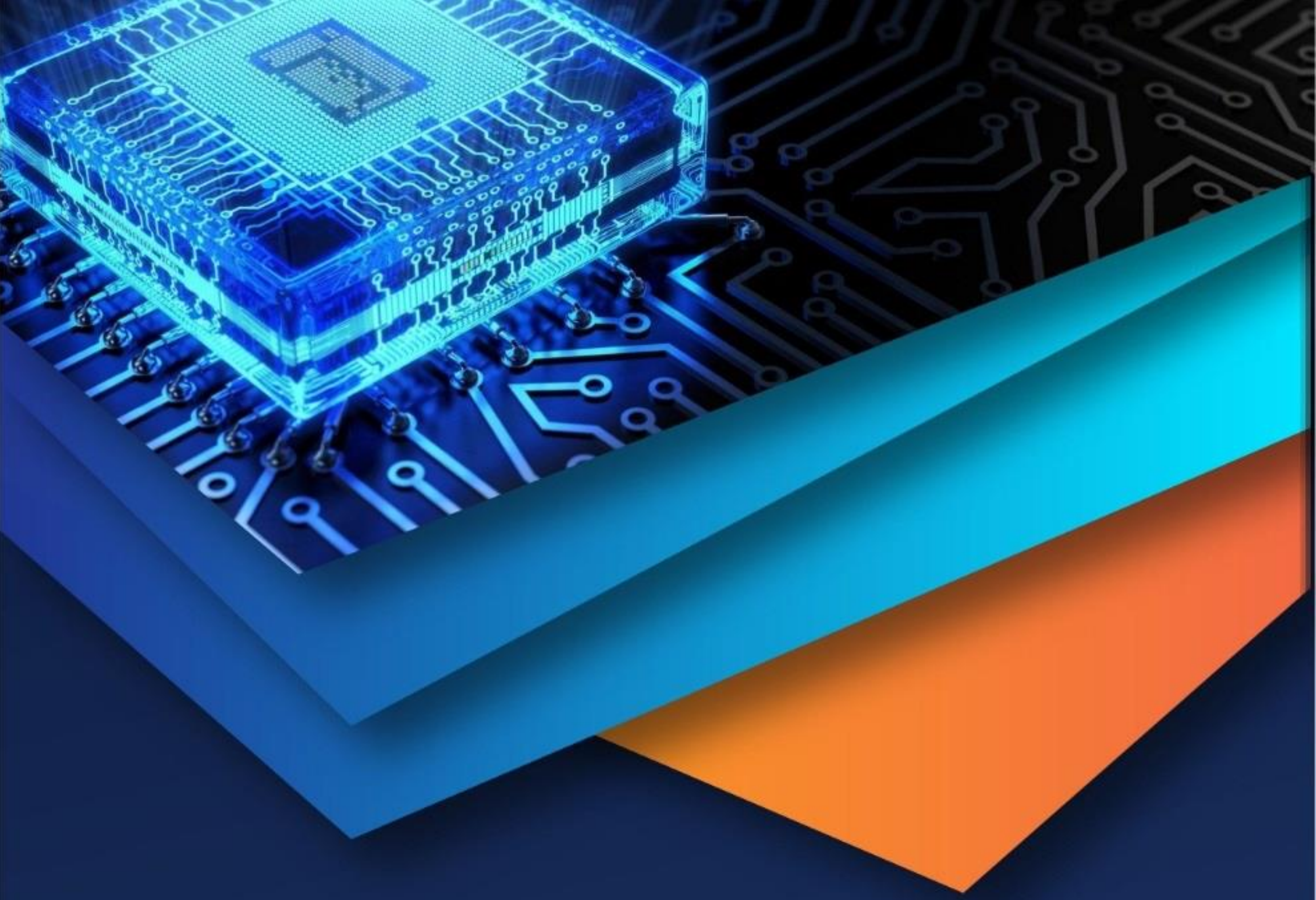

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