EXPERIMENTAL STUDY ON DEVELOPMENT OF CORRELATION BETWEEN CBR AND DYNAMIC CONE PENETROMETER TEST

Er. Sobiya Sidiq[1], Dr. Rajesh Goyal[2],

[1]PG Research Scholar, Dept. of Civil Enggineering, MIET Kurukshetra, Haryana, India
[2] Professor Dept. of Civil Enggineering, MIET Kurukshetra, Haryana, India

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Abstract - *The development of new roads, enhancement of existing roads and new runways are part of infrastructural boom in India. The foremost step in the design of road pavements has always been the geotechnical evaluation of sub-grade soil material, irrespective of whether it is used in filling or cutting..The significance of this parameter lies in the critical design parameters like CBR (as per IRC-37[1] and MORTH[2]). CBR (California bearing ratio), gives realistic results which aids the design process of new flexible pavements as well as the restoration of existing pavements all over the world. The conventional CBR test procedure has always been time consuming, relatively expensive and has generally low repeatability. The repeatability has been found extremely low when it comes to sensitive soils like Lacustrine soils, locally known as Kerawa soils in North India. All these hindrances indicate that the present study should be carried out using Dynamic Cone Penetrometer (DCP). The DCP has been widely used to evaluate the in-situ strength of undisturbed soil and compacted sub-grade materials. The present study aims at developing a correlation of DCP test values with the CBR test values for Lacustrine (sedimentary upland) soil formations so that a quick assessment of road sub-grades can be made. Analysis of experimental data indicated that there is a very good relationship of the measured soil strength (i.e., unsoaked California Bearing value and Dynamic cone penetration values) with the soil initial state factor as described by the combination of initial dry density, water content and void ratio. Comparison of measured and predicted values of soaked CBR and DCP using the developed equation clearly indicate the validity of equation.*

***Key Words*: *California bearing ratio*, *Dynamic cone penetration*, *Lacustrine deposited soils* , *Hill or mountain forest soils*.**

1. INTRODUCTION

The projects of road and infrastructure development have always been of great concern for the government of Jammu & Kashmir. The government allocates huge funds to various concerned departments like R&B (Roads and Buildings), PMGSY (Pradhan Mantri Gram Sadak Yojna) and other corporations for planning, construction, execution, development and maintenance of various road related projects within the state of J&K. The emphasis is led on the timely completion of projects which becomes a major concern for all the executing agencies. Every road project initiates from a very basic survey followed by sub-grade investigations which helps in the formation of DPR (detailed project report) later.

1.1 Types of soil in Kashmir valley

1.1.1. ***Degraded or grey brown podzolic soils***: are of loam to clay texture at their surface and clay loam to clay texture at their sub-surface and of fine granular well developed angular block structure.

1.1.2. ***Hill or mountain forest soils***: These are sandy loam to loamy, fine to weakly granular moderately alkaline (pH 7.4 – 8.4) and calcareous (4 to 10% calcium carbonate) soils.

1.1.3 ***Mountain meadow soils***: They are alkaline (pH more than 7 – 9) and high in organic carbon.

1.1.4 ***Alluvial soils***: They are situated in the flood plains of Ravi, Chenab, Jhelum and Sindh rivers and their tributaries. They are old and new alluvial soils. Old alluvial soil contain high amounts of Calcium Carbonate and are slightly to moderately alkaline (7.0–7.7) organic carbon between 0.28 – 0.61%.

1.1.5 ***Lacustrine deposited soils:*** These soils are deposited in lakes. Lacustrine deposited soils are laminated or varved in layers.

2. TESTS

These tests was performed to know the coorelation between CBR and DCPT

2.1 Dynamic cone penetrometer test

The Dynamic Cone Penetration Test (DCPT) is a widely-used and very simple test for evaluating soil compactness and load-bearing capacity and thus can be successfully for estimating the strength of soil.

2.1.1 Need of Test

a) It may help to raise highway construction quality control;
b) It may help to ensure long-term pavement performance and stability;
c) The DCPT test values can be used to calculate the CBR values only if a suitable relationship exists between the CBR and the DCPT value.

2.2 California Bearing Ratio Test

CBR is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min. to that required for the corresponding penetration of a standard material. Tests are carried out on natural or compacted soils in water soaked or un soaked conditions.

2.2.1 Need of Test

The test is performed for evaluating the suitability of the subgrade and material used in sub-base and base of a flexible pavement.

3. GAP IDENTIFICATION AND NEED OF STUDY

3.1 GAP IDENTIFICATION

3.1.1 No study, as such has correlated both these test results to find an accurate correlation which can make field evaluations and computations easy to a great extent.

3.1.2 These studies include soil types which are not found in the state of J&K, which is our study area, hence it became a positive aspect to take up this study as a part of this research project.

3.1.3 Various types of soils behave differently to different conditions as has been found during the experimentation as well as from the studies aforementioned, thereby, giving more advantage of taking up different soil samples for evaluation and development of correlation.

3.2 NEED OF STUDY

The study area, that has been taken up for this project, is dynamic in terms of soil types, that is, numerous soil types are found in the state of J&K which have not been studied so far to a great extent. After referring to the literature of geotechnical evaluation of soil of J&K, the need of the study was felt, as not much work has been done on it. There are various types of soil deposits in the valley which need to be studied so that the nature and behavior of soil upon different atmospheric conditions can be observed, which can help further to develop certain correlations among different soil types. Hence, the different soil layers can be evaluated on that basis. The study can be helpful for the overall development of the state.

4 OBJECTIVES

The primary objective of the proposed project, **"Experimental study on development of correlation between CBR & Dynamic Cone Penetration Test"**, is summarized below:

I. To see the variations and observe the dynamic nature of soil within the state of J&K;
II. To yield a relationship between dynamic cone penetrometer tests and CBR of soils under study;
III. To develop a sound correlation between results of Dynamic cone penetrometer with CBR of sub-grade soil material under in-situ and laboratory remoulded conditions.
In due course of time, if a strong data base is generated for the above mentioned relation (DCP vs CBR), it can be used to facilitate quick evaluation of road sub-grades based on mere test results.

5 EXPERIMENTAL PROGRAM

On the whole, 17 soil samples were tested which include 8 samples of Alluvial soil deposits and 7 samples of Lacustrine soils. Lacustrine samples were collected from eastern side of river Jhelum in Pampore region (Alluvial), Budgam which possesses loose soil and mostly denuded Karewas and Pattan area (Karewas) of Kashmir valley. The Alluvial soil has also been collected from Rambagh and GogjiBagh area.

5.1 PROPERTIES OF DIFFERENT SOIL SAMPLES

Table 1: Properties of Soil Samples

Type of soil	%age of gravel	%age of sand	%age of silt-clay	Specific gravity	Liquid limit %	Plastic limit %	Optimum moisture content %	Maximum dry density
Alluvial	0.85	5.90	93.25	2.69	35.0	20.70	18.6	1.73
Alluvial	3.12	11.10	85.82	2.54	40.83	25.69	19.55	1.64
Alluvial	1	4.20	94.80	2.63	38.60	21.78	19.57	1.67
Alluvial	0	1.40	98.60	2.59	34.18	21.39	20.30	1.59
Alluvial	7.56	18.31	74.10	2.50	38.30	26.44	22.5	1.6
Alluvial	17.9	20.40	61.75	2.52	38.0	25.83	14.2	1.76
Alluvial	11.4	21.90	66.70	2.59	29.0	19.85	17	1.7
Alluvial	23.55	43.35	33.10	2.51	32.35	19.73	17.1	1.74
Lacustrine	0	1.19	98.81	2.61	32.50	16.94	17.80	1.73

Lacustrine	48	2.86	92.33	2.55	33.78	20.26	20	1.63
Lacustrine	2.08	4.75	93.17	2.67	33.19	20.12	19	1.69
Lacustrine	11.5	3	85.20	2.43	30.15	25.80	21.15	1.66
Lacustrine	2.6	3.5	93.50	2.34	34.40	19.60	19.5	1.64
Lacustrine	1.2	6.75	92.50	2.53	30.80	21.49	19.5	1.64
Lacustrine	0.6	3	95.93	2.52	31.50	19.94	18.65	1.67
Lacustrine	0.95	2	97.05	2.37	31.15	21.34	22	1.58
Lacustrine	0	2.80	96.57	2.40	31.9	19.54	20	1.65

6. RESULTS AND DISCUSSIONS

6.1 TEST RESULTS IN TABULATED FORM

Table 2: TEST RESULTS

Site No.	$\rho_{b(UDS)}$	$\rho_{d(UDS)}$	$N_{c=10}$	$N_{c=15}$	$N_{c=20}$	$N_{c=25}$	CBR_{UDS}	MDD	CBR_{US} at MDD	CBR_s At MDD
1	1.61	1.34	1	1	2	2	1.04	1.73	-	2.41
2	1.75	1.42	4	6	7	9	8.88	1.64	-	11.95
3	1.58	1.33	8	9	11	12	3.90	1.67	-	10.85
4	1.89	1.47	2	3	4	4	5.69	1.59	1.22	0.95
5	1.51	1.33	2	2	3	5	4.12	1.60	0.74	0.70
6	1.73	1.54	7	10	13	16	8.18	1.76	6.44	4.04
7	1.69	1.46	5	8	11	12	7.83	1.77	1.33	1.22
8	1.75	1.47	3	8	14	19	8.27	1.74	8.80	4.50
9	1.69	1.50	8	14	20	25	12.32	1.73	1.93	0.98
10	1.49	1.33	9	16	25	33	10.50	1.64	0.85	0.74
11	1.64	1.45	6	11	17	22	10.75	1.69	1.61	1.50
12	1.67	1.56	10	13	16	18	9.49	1.66	1.90	1.87
13	1.65	1.47	8	12	16	21	10.17	1.64	2.08	1.71
14	1.56	1.46	7	11	18	30	9.03	1.64	1.31	1.02
15	1.55	1.48	16	24	29	35	28.07	1.67	7.41	4.72
16	1.53	1.47	12	18	21	24	3.79	1.58	2.45	2.26
17	1.50	1.45	9	14	19	26	15.48	1.65	6.89	4.92

6.2 TEST RESULTS IN GRAPHICAL FORM

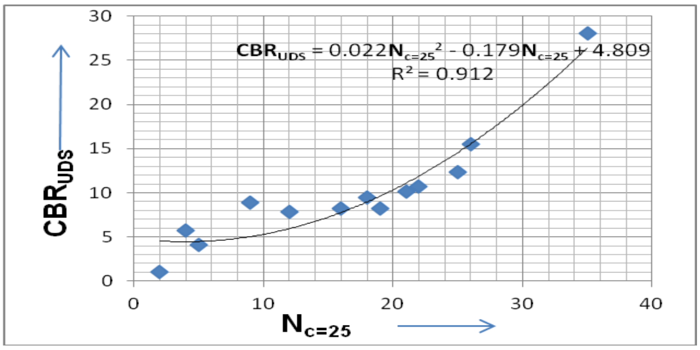

Chart -1: Correlation of CBR_{UDS} & Cumulative no. Of blows for 25mm penetration

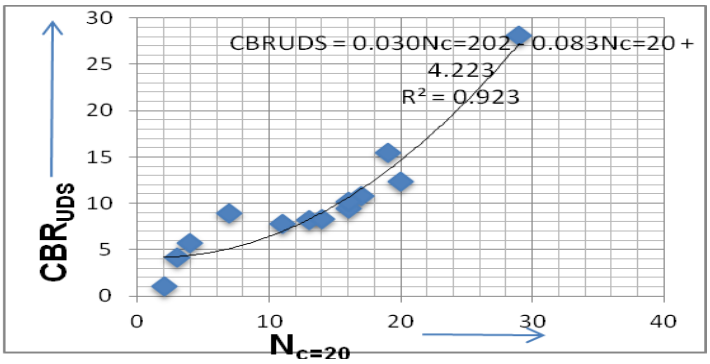

Chart -2: Correlation of CBR_{UDS} & Cumulative no. Of blows for 20mm penetration

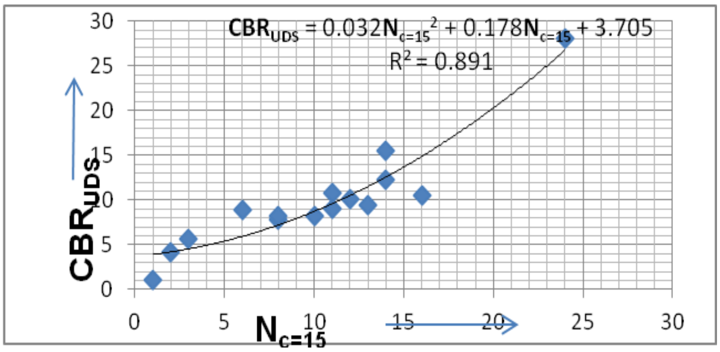

Chart -3: Correlation of CBR_{UDS} & Cumulative no. Of blows for 15mm penetration

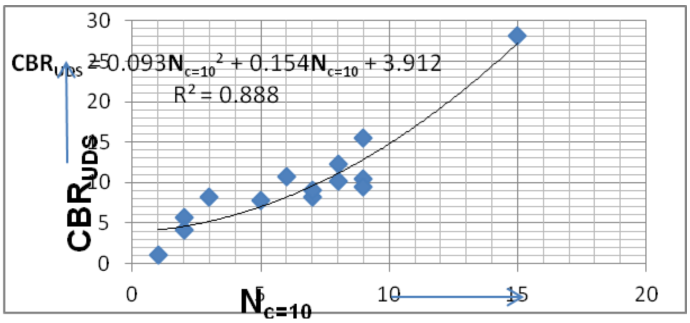

Chart -4: Correlation of CBR_{UDS} & Cumulative no. Of blows for 10mm penetration

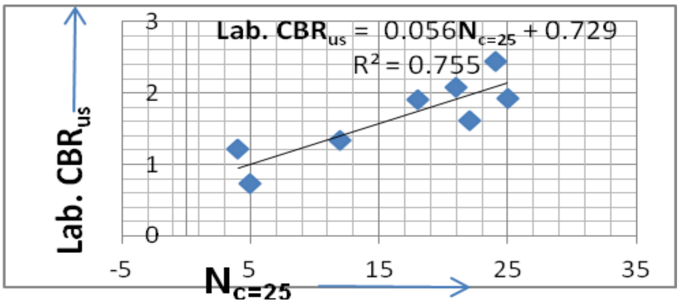

Chart -5: Correlation of CBR_{US} & Cumulative no. Of blows for 25mm penetration

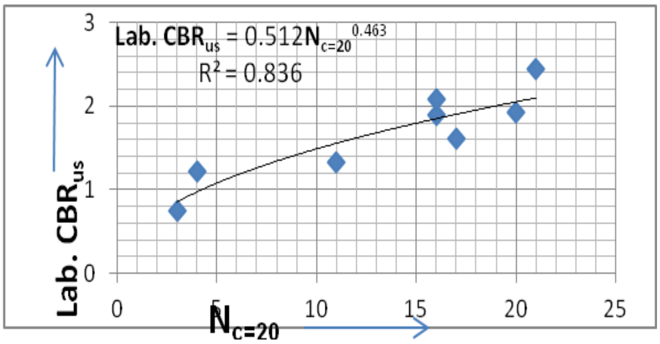

Chart -6: Correlation of CBR_{US} & Cumulative no. Of blows for 20mm penetration

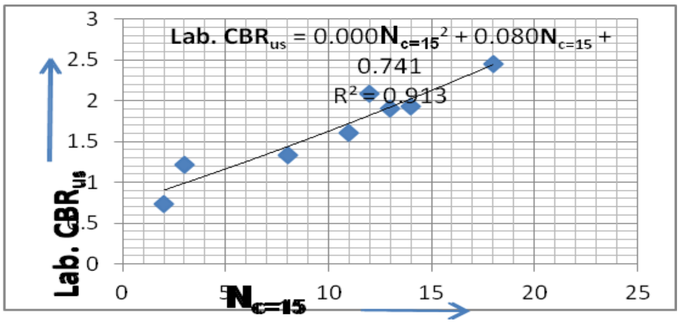

Chart -7: Correlation of CBR_{US} & Cumulative no. Of blows for 15mm penetration

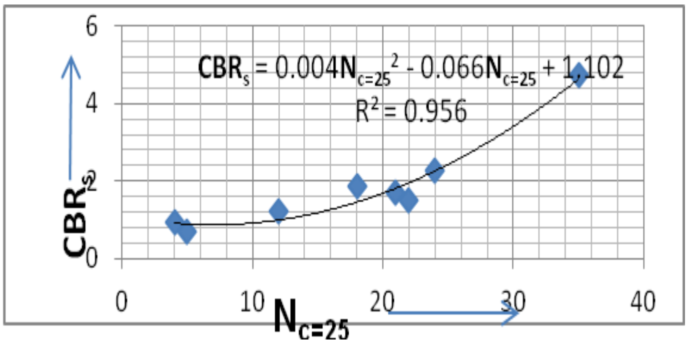

Chart -8: Correlation of CBR_S & Cumulative no. Of blows for 25mm penetration

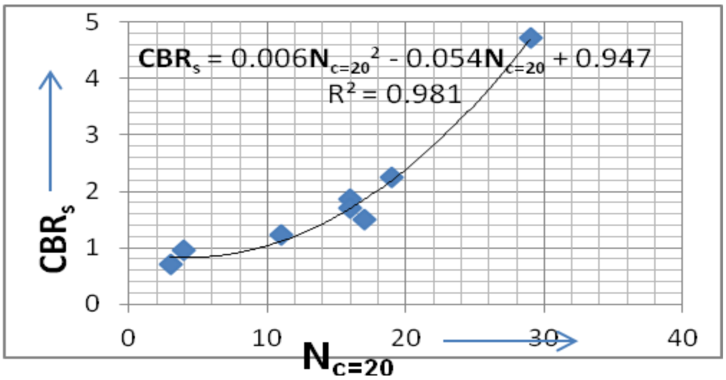

Chart -9: Correlation of CBR_S & Cumulative no. Of blows for 20mm penetration

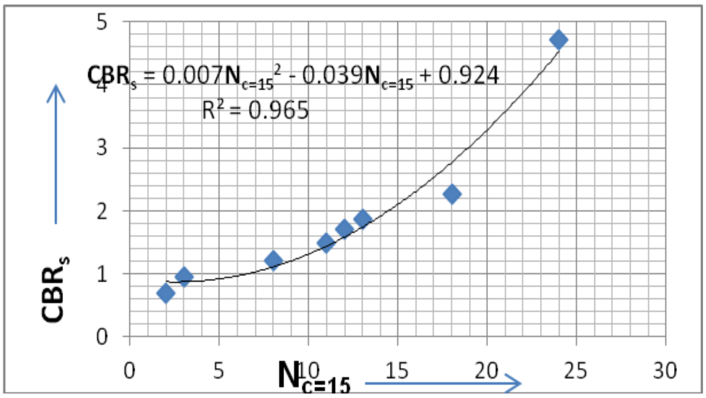

Chart -10: Correlation of CBR_S & Cumulative no. Of blows for 15mm penetration

7. CONCLUSIONS

1) It is found that best plot for correlation between CBR_{UDS} and DCPT follows a polynomial of order 2 (for all cases that is $N_{c=10}$, $N_{c=15}$, $N_{c=20}$, $N_{c=25}$).
2) It was found that the best plot for correlation between CBR_{us} and DCPT follows a polynomial of order 2 (with $N_{c=15}$ and $N_{c=25}$) and that with $N_{c=20}$ is a power equation.
3) It is found that best plot for correlation between CBR_S and DCPT follows a polynomial of order 2 (for all cases that is $N_{c=15}$, $N_{c=20}$, $N_{c=25}$).
4) The correlation developed for undisturbed, soaked and unsoaked samples have been found satisfactory as R values for most of the cases is above 0.9.
5) Once the correlation is established between CBR index for tests conducted under different conditions and compaction level or in-situ density. The soaked CBR value in the field can be determined very rapidly by conducting the in-situ DCPT for existing conditions and using the CBRI value for that particular condition.

6) Penetration resistance observations from DCP test and California Bearing Ratio Test results show that CBR-value increases with increase in DCPT values.
7) Good relations between PR and other common soil property parameters discover that DCP testing is a reliable means of measuring subgrade stiffness and base. DCP testing hence should be accepted as an alternative means of doing so, and the engineer should be able to present the in-situ stiffness of subgrade and base directly in terms of PR.

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