CORRELATION BETWEEN SOAKED CBR VALUE AND CBR VALUE OBTAINED WITH DYNAMIC CONE PENETROMETER

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ABSTRACT

For the design of flexible pavement, the sub-grade soil strength is estimated with California Bearing Ratio test (IRC-37-2001). In 1929, this test was developed by California Division of Highway and is used to evaluate the suitability of sub grade and the materials used in sub base and base course. This test can be done in the laboratory as well as in the field. But this conventional CBR testing has low repeatability. It is an expensive and time consuming test. Moreover, it is very difficult to mould the sample at desired insitu 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 insitu strength of pavement base , sub base and 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 road.

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1. INTRODUCTION

C.B.R. is empirical test developed in 1928-29 and is widely applied in design of flexible payment over the world. This test was introduced during 2nd world war in USA and now it is being used as standard method of design in other parts of world. But due to its imperialness (Brown, 1996) it is recently being discouraged in some advanced countries because CBR test procedure is costly and a lot of time is required to perform this test. This test also required a large amount of soil sample for the laboratory test. Due to these reasons, the other test method (Dynamic cone penetrometer) is now extensively being used in the field by several countries. DCP Index is an index value which is used to represents the strength of subgrade soils at low cost. To estimate CBR value DCP test values can be used to provide a suitable relationship exists between the both (DCPT & CBR value). So developed relationship between them may be very effective tool for the highway engineers. DCPT is very easy test and performed in the field at in situ conditions in very less time. This test ensure the long term pavement performance and also help to achieve the more uniform structural property. In this present study, six locations were selected in the field which are at the interval of 1 km from each other along the Gill Road to Alamgir starting from 0 KM at side of G.N.D.E. College, Ludhiana (Punjab). The six locations were selected on basis of uniformity of soil along the road. The DCP tests were conducted at these locations at in situ conditions (soaked). Then the soil samples were taken for laboratory tests (soaked CBR test) from each location. The results obtained from both (DCPT & CBR) methods are presented in this paper.

2. EXPERIMENTAL WORK

According to the procedure laid down in ASTM-D6957-3(2003), the DCP tests were conducted at all six locations. The DCP consists of a rod of 16 mm dia and a tempered steel cone of 20 mm base dia and a 60 degree point angle, which is attached to rod. This penetrometer is driven in the soil with a 8 kg hammer with a free fall of 575 mm. The correction factor is unity for 8 kg hammer. The dimensions of the D.C.P. is shown in the figure below :

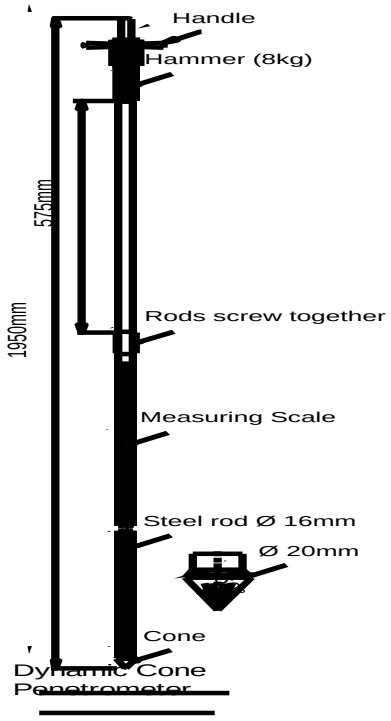

Fig. 1. Dynamic Cone Penetrometer

The DCP index is depth of penetration (mm) for a single drop of hammer. This cone is driven into the material upto desire depth by this hammer which is falling, from a distance of 575 mm on to an anvil attached to penetrometer rod and then the average DCPI is calculated for a single below.

Series of tests performed in the field and laboratory :

The following tests were conducted in this study :-

1. In situ density test (sand replacement method)
2. DCP test (soaked condition)
3. Sieve Analysis
4. Atterberg's limit.
5. Laboratory CBR test (soaked condition at in situ density)

3. SAMPLE PREPARATION FOR SOAKED CBR TEST

To find the soaked CBR value at in situ density, the specimens were prepared in the laboratory by varying the number of blows at different compaction levels. In this study, four compaction levels i.e. 10, 25, 35 and 55 bellows were adopted for different percentage of water. The in situ densities were calculated for the different compaction levels and the graph is plotted between the in situ density and number of blows. Hence, the number of blows

calculated from that graph corresponding to the desired in situ density were used to prepare the sample in the CBR mould. The Fig. 2 is showing a typical variation between the dry density and the number of blows and the similar results were obtained for the other locations also.

Table 1: Dry densities for different no. of blows:

S. No.	No. of blows	Dry density (KN/m^3)
1	10	14.2
2	25	16.65
3	35	17.72
4	55	19.4

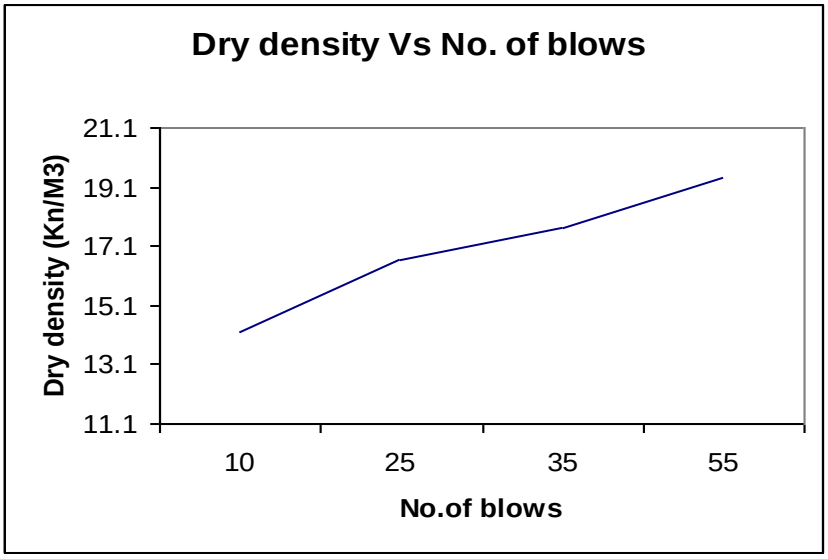

Fig. 2. Variation Between Dry density and No. of blows

4. THE OTHER TEST PROCEDURES

The other tests were performed in the laboratory were according to IS Code. The sieve analysis and the Atterberg's limits were found in the laboratory. Sand replacement tests were performed at each location in the field to find the in situ density. The DCP tests were done on all six locations for soaked condition at existing sub grade surface to calculate the CBR value at in situ densities.

At every location three different points were selected and the average CBR values from these three locations were calculated based on DCPI. To conduct DCP test in soaked condition, the

3m x 3m area was flooded with water by constructing dykes around that area. The sites were kept flooded before conducting DCP test for 8 hrs, because the soil tested was silty sand. Measurement for soil resistance was done in terms of DCPI (mm/blow). For 500 mm penetration of cone, the numbers of blows were counted and then penetration per blow was calculated.

To determine the C.B.R. value, following co-relation was used, which is suggested by ASTM 6951-3(2003).

$$CBR = \frac{292}{(DPI)^{1.12}}$$

Where DPI is Dynamic Cone Penetration Index and it is equal to penetration per blow.

5. RESULTS AND DISCUSSION

The following table is showing the results of various tests performed in laboratory and in the field:

Table 2. Laboratory and InsituTest Results at Different Six Locations:

Location Nos.	Chainage from G.N.D.E.C (km)	In-situ water content (w%)	Optimum moisture content (%)	Maximum dry density (KN/m^3)	In-situ dry density (kN/m^3)	%age compaction	Sand %	Liquid Limit (%)	Plasticity Index (P.I) (%)
1.	0	8.69	9.8	19.10	17.9	93.71	65	19	Non-plastic
2.	1	5.26	9.5	19.06	18.1	94.96	66	18	Non-plastic
3.	2	3.62	9.8	19.20	16.4	85.41	60	19	Non-plastic
4.	3	7.56	10.2	19.36	17.2	88.84	58	20	1
5.	4	2.04	9.9	19.25	14.2	73.76	52	18	Non-plastic
6.	5	2.04	9.85	19.25	17.7	91.95	55	18	Non-plastic

So in these results, it can be observed that soil at all six locations are almost uniform with

sand content varying from 52% to 66%. Nature of soil is non plastic. The liquid limit is raging between 18% to 20%. In situ moisture content lies in the range of 2.04% to 8.69% and in situ density at that locations are varying from 3.89% to 8.6%. It is observed from the table given below that DCPT based on CBR values for soaked condition is less than the CBR values obtained for soaked CBR tests. This is due to higher confinement pressure in the rigid mould using in the test procedure of soaked CBR tests.

Table 3 : Comparison of CBR values based on Soaked DCPT with conv. soaked CBR values

Location Nos.	Conv. Soaked CBR Values as per code-IRC-37-2001 (%)	CBR Value based on Soaked DCPT (%)	(%)Difference
1	6.9	5.75	16.67
2	8.6	7.49	12.91
3	5.98	4.9	18.06
4	7.07	5.75	18.67
5	3.89	3.24	16.71
6	7.39	5.91	20.03

It has been observed from the above table that the variation between CBR values based on Soaked DCPT and conv. soaked CBR values is in the range of 12.91% to 20.03%.

The graph given below is showing the relationship between the soaked CBR value and soaked DCPT based CBR values at different locations.

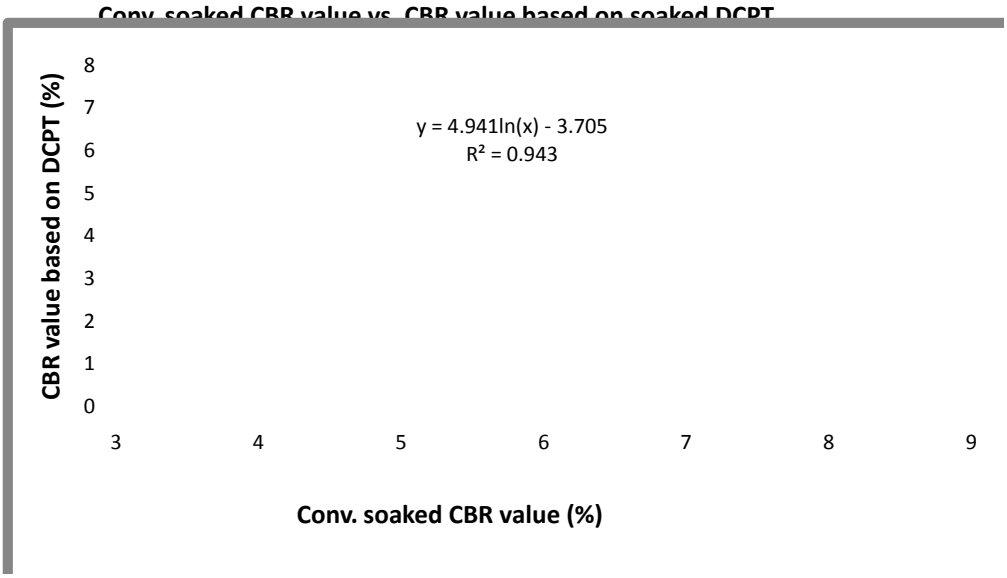

Fig.3: Comparison of conv. soaked CBR values with CBR values based on Soaked DCPT

So, the correlation between conv. soaked CBR values with CBR values based on Soaked DCPT is given below :

$y = 4.941 \ln(x) - 3.705$

Where y is Soaked CBR value and x is CBR value based on DCPI.

6. CONCLUSIONS

The following conclusions can be drawn on the basis of this study.

1. The soaked CBR values of uniform soils which has similar characteristics can be determined quickly and will have adequate accuracy using DCP test results.
2. For existing conditions, the in situ DCPT can be conducted for determination of field CBR value for in situ density.
3. It may be helpful to control quality and achieving more uniform structural property in enhancing highway construction.

7. REFERENCES

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