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Correlation Between California Bearing Ratio (CBR) Value and Index Properties of Soils for Gangetic Alluvium in West Bengal

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1.0 INTRODUCTION:

Large scale infrastructural development by constructing huge amount of roads connecting remotest villages in rural India with the existing network of road is being pursued rigorously in India from last decade, through different government scheme, like PradhanMantri Gram Sadak Yojana. The process is involving year long selection of possible routes at block level decided from lowest administrative level district wise for making planning design, and scrutinizing them at state level before sanctioning by national authority. For such roads, near surface local soil, enroute are used as constructional material for sub-grade construction and foundation material for the road structure itself. These soils vary widely with location.

In India major part of southern part is covered with Black cotton soil, while great part of north Indian planes are covered with Indo-Gangetic alluvium. Alluvial soils due to their modes of formation are very erratic and properties of such soil vary greatly along horizontal and vertical directions. To map such variation by determining their insitu properties is very costly and may be kept out of considerations generally, due to economic difficulties. But consideration of such variation in engineering properties of soil becomes important from view point of design, construction control, satisfactory performance, and cost effectiveness. There have been studies to map the possible variation for different types of soil in different countries by classification system world wise. Such investigation try to scale the variation of studied soils by zonalising so that designer and constructors can estimate possible variation of the properties of soils existing at those sites.

1.2 CALIFORNIA BEARING RATIO

California bearing ratio test is an empirical one and results of such test are widely used in design of flexible pavement in the world. This is also used to the design of rehabilitation of old pavements to determine the overlay thickness. The method was originally developed at California division of highway during 1928-29 to provide assessment of the relative stability of fine crushed rock base materials. Use of CBR test results for design of roads was introduced in USA during 2nd world war and subsequently adopted as standard method of design in other part of the world. Flexible pavement design in India was standardize in 1970 by the India Road Congress (IRC) which gave design curves from which the thickness of different pavement layers for a given traffic load and CBR usually on subgrade soil (IRC: SP : 20-2002, IRC SP 72-2007). Though some reservation against the adoption of CBR method for design of flexible road pavement has been voiced in Western Countries due to empiricalness of the method (Brown – 1996), CBR method of design of flexible pavements is most widely accepted method (Rao,2004,Rollinganl Rolling 1996).

However to conduct a CBR test representative soil sample has to be collected from location selected, from which a remolded specimen has to be prepared at predetermined optimum moisture content (OMC) and maximum dry density (MDD) with standard proctor compaction for the test to be conducted. To obtain soaked CBR value of a soil sample, it takes about a week making CBR test expensive, time consuming and laborious. Improper handling and poor quality of testing conditions in hurriedly established field laboratories for temporary purpose in sites may have some reservation about the accuracy of the result produced.

As a result only limited number of CBR test could be performed for kilometer length of the proposed road to be constructed, for preparation of detailed project report (DPR) needed for sanction of fund for construction and finalizing the design of road structure. Such limited number of CBR test results may not generally reveal the variation of CBR values over the length of the road to enable rational, economic, and safe construction. This is particularly true for road construction on alluvial soils which by nature of their development are extremely erratic in nature, In such cases, only limited number of CBR test values along the

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alignment of the road, makes difficult for High way engineers to incorporate the in-situ variation of soil properties of subgrade along the length of the road properly and also take rational steps to identify and rectify the local weakness present at any location if any, along the length of the road.

This could only be avoided if large number of soil sample is taken at short interval throughout the road length and necessary CBR test are conducted. But such procedure will escalate the project cost and time. This problem not only arises during design before construction but also during the after construction at the time of the checking the quality of construction by comparing the CBR values of constructed portion with the design value. In present scenario quality control has became very important component of road project. Such quality checking is practically becoming very difficult due to time and cost of getting CBR values at a chosen and doubtful location is a reasonable period of time. (Chattopadhyay and Maity 2012)

In most of modern day projects the material for earth work and construction come from highly variable sources and the engineering property of such soils after specified compaction will be varying to a large degree. In such cases economy that may be achieved by intensive testing to determine soil properties is out weighted by the economy due to saving in time by reasonably accurate quick production (Vinod and Cletus 2008). Thus for cost effectiveness and quick methods to evaluate the properties of sub grade soil particularly CBR value, on the basis of low cost, easy to perform, and less time consuming test, becomes important and necessary both design stage and quality checking stage. (Roy et al 2009). Development of prediction models might be useful and became a base of judgment on the validation of CBR values

2.3 REVIEW OFAVAILABLE CORRELATIONS FOR CBR

Attempts have been made by several research scholar to develop suitable correlation between CBR values of compacted soils at optimum moisture content (OMC) and different simple soil characteristics or result of some simple field tests and laboratory tests.Reviews of these correlations are presented below.

Availablecorrelations in present literature may be grouped into two classes. In one class, simple field test results are correlated with CBR value, while in second class different simple fast and easy to perform laboratory test result have been correlated with CBR value of the soil. These correlations are described below.

2.3.1 Available Correlations Between CBR And Simple Field Test Result.

Correlations with Dynamic Cone Penetration (DCP) Resistance

The Dynamic Cone Penetrometer is an instrument which is designed for the measurement of the structural properties of the existing road pavement. The Dynamic Cone Penetrometer is quick and easy to use, portable and suitable for use in locations where access may be difficult. A typical test takes only a few minutes and therefore the instrument provides a very efficient method of obtaining information. Therefore, correlations between CBR value and DCP value have been proposed by different researchers in different times, so that , CBR value can be obtained very easily by knowing the Dynamic Cone Penetration value.

A. In1975, Kleyn, proposed a correlation between CBR value and DCP value. He proposed :

$$\log(CBR) = 2.62 - 1.27 \log(DCP)$$

B. In 1987, Livneh made his research on Granular and cohesive soil and proposed a correlation between CBR value and DCP value. He proposed :

$$\log(CBR) = 2.56 - 1.16 \log(DCP)$$

C. In 1987, Harison also carried out his research on Granular and cohesive soil and proposed a correlation. He proposed:

$$\log(CBR) = 2.55 - 1.14 \log(DCP)$$

D. In **1992, Livneh et al.** made elaborate study on CBR on Granular and cohesive soil and proposed a correlation as below.

$$\log(CBR) = 2.45 -. 1.12 \log(DCP)$$

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E. Later in **1992, Webster et al.** carried out research on CBR on different types of soil and proposed that:

$$\log(CBR) = 2.46 - 1.12 \log (DCP)$$

F. In **1995, Ese et al.** proposed an another correlation. They carried out detailed study on aggregate base course and proposed that:

$$\log(CBR) = 2.44 - 1.07 \log (DCP)$$

G. In **1998, North Carolina Department of Transportation (NCDOT)** proposed a correlation between CBR value and DCP value. They used aggregate base course and cohesive soils for their research .They suggested :

$$\text{Log}(CBR) = 2.60 - 1.07 \log (DCP)$$

H. In **1999, Coonse**reported work on Piedmont residual soil and proposed that:

$$\text{Log}(CBR) = 2.53 - 1.14 \log (DCP)$$

I. Karunaprema and Edirisinghe (in 2002) investigated for similar relationship forClayey gravel and silty gravel of SriLanka and proposed a correlation between Dynamic Cone Penetration (DCP)value and CBR value.

They proposed:

$$\text{Log}\ (CBR_{unsoaked}) = 1.966 - 0.667 \text{LogDCP}$$
$$CBR_{unsoaked} - CBR_{soaked} = 67.12 - 1.48W - 30.64DCP^{1/W}$$

Where,

DCP = Dynamic Cone Penetration.

W = Moisture Content(%).

J. In 2009,Sahooet. al. proposed a correlation between CBR value and DCP value. He proposed
$CBR=67.687(DCP)^{-1.1029}$

K. In 2010, Gupta, Kumar and Rastogi conducted experiment to find a correlation between CBR value and DCP value. There Field evaluation was carried out on thin bituminous surfaced granular pavements constructed under PMGSY programme in Uttar Pradesh and Uttarakhand states of India. They proposed

$$CBR= 35.476(DCP)^{-1.28}$$

L.In 2012,**Desalegn ,** made his research to find the correlation between Cone Penetrometer (DCP) with CBR values that best suit the type of soils in Ethiopia. Accordingly, several laboratory tests and field tests he proposed a correlation

$$\log\ (CBR) = 2.954 - 1.496 \log\ (DCPI)$$

The relation obtained from statistical analysis has an R^2 value of 0.943.

The results of the statistical analysis show that good correlation does exist between the dynamic cone penetration indexes (DCPI) and unsoaked CBR values.

Correlations With Clegg Impact Value (CIV).

One simple device for the measurement of strength and stiffness of soil layers is the clegg Impact Tester. The Clegg Impact value(CIV) given by the machine is the resistance offered by the top soil of about 25 cm thickness against a falling hammer of standard weight.

The Clegg Impact soil Tester is commonly used inBretain.

As the CIV too is a measure of soil strength, research works were carried out to examine the possibility of correlating the same with CBR values and these co relations are found.

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A. In **1995 ,Venkataraman et. al.** developed an equation, besed on his experiments , conducted on soil mixtures with different combination of Sand and Gravel.

CBR(%) = 1.3728(CIV) + 0.868
The above Equation has a correlation coefficient (r) = 0.9
This equation shows a very good result for Laterite or Lateritic soil.

B. Later,In**2000,Kumar et. al.** proposed an another co rrelation which shows a very good result for Alluvial Soil,B.C .Soil,Gravel,Moorum etc. He proposed:
$CBR = 0.0039[CIV]^{1.94}$

C. To find a better result for all types of soil, **Omar et. al.** proposed an another correlation in **2002**.
CBR = 0.169[CIV] + 1.695

D. Later, in **2003**,**Chandrasekhar et. al.** proposed an another correlation for Lateritic soil .They developed the equation based on his laboratory test result of soils which was collected from Tirupati Town. He proposed that:
CBR(%) = 1.1242(CIV) – 0.3466

Correlation With Load Bearing Capacity:

A. In 1950,Wilson and William"s proposed a correlation between CBR and Load Bearing Capacity of soil. They suggested :
$CBR = q_u/10$
Where, q_u = Ultimate Load Bearing Capacity of soil.

B. Later, In 1980, Kate's proposed an another correlation .He suggested that:
$CBR_{(lab)} = 1.35CBR_{(field)}$
In this relationship the $CBR_{(field)}$ determined at 5mm penetration is assumed to be correlated to the ultimate bearing capacity by following equation :

$CBR_{(field)} = q_u(kn/m^2) / 103$

C. In 2007,Gregory& Gross proposed a correlation between CBR and Load Bearing Capacity For cohesion less soils. They suggested:

$CBR = q_{ult} * 100/6895$
Where, q_{ult} = Ultimate Load Bearing Capacity of soil in kPa

AVAILABLE CORRELATIONS BETWEEN CBR AND SIMPLE LABORATORY TESTS

In **2008, Vinod and Cletus** gives a correlation between CBR and Liquid Limit of soil .He had done a lot of experiment to develop the equation. He collected a large number of Lateritic soil sample from different part of South India(Thiruvananthapuram,kollam etc).

He proposed that :

$CBR = - 0.889 (W_{LM}) + 45.616$

Where,

W_{LM} = Modified Liquid Limit = LL (1 - C/100)

LL = Liquid Limit of soil passing 425 micron sieve (in percent).

C = fraction of soil coarser than 425 Micron sieve (in percent).

[The F and T values of the proposed equation are

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$F=536.421$; $F_{@99\% \text{ confidence limits}}=7.88$ and

$T=23.161$;$T_{@99.5\% \text{ confidence limits}}=2.069$

The correlation coefficient(r) of the equation=0.979

In 2010,**Ferede**Proposed a simple correlation to predict the soaked CBR value for **Silty-Clay. He proposed:**

$\text{Ln CBR} = 4.175 – 0.029*LL -0.009* P_{200}$
Where,
P_{200}=Percentage of soil particle which is passing 200micron Sieve

In **1962,Black** developed a method of estimating the CBR value for cohesive soil .He correlated the CBR value with Plasticity Index for different values of liquidity index as shown in figure(a).

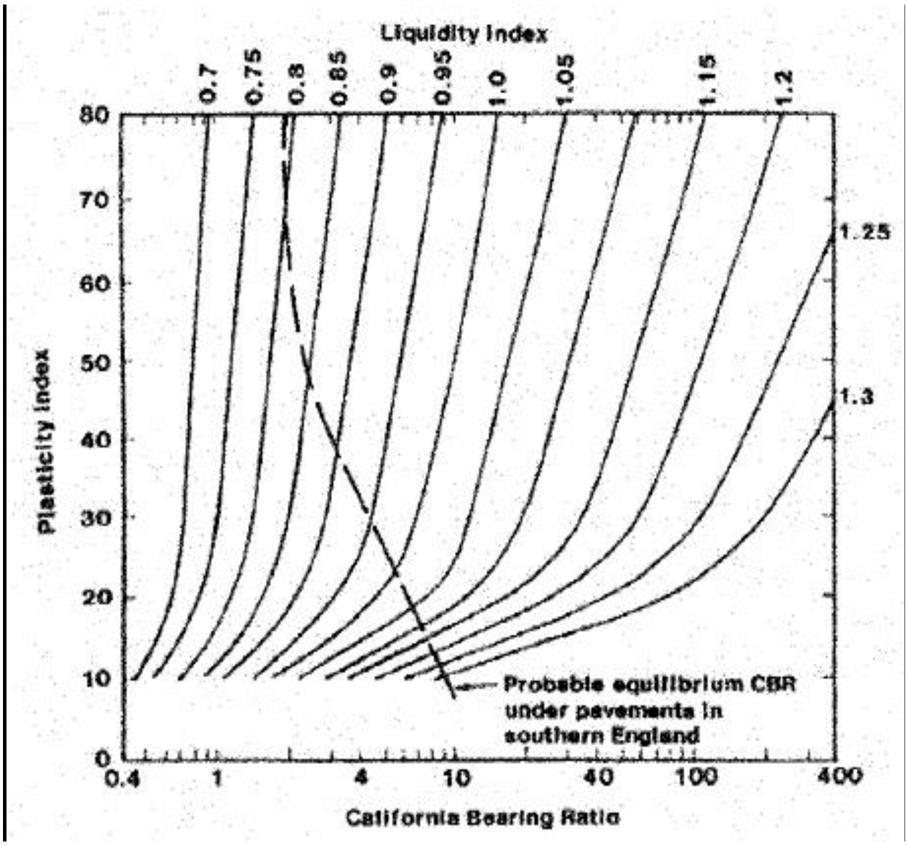

Fig:**(a).**Prediction of CBR value from Plasticity Index for different values of liquidity index

He also suggested that,the values are given in the figure , refer to saturated condition only. For unsaturated soil condition ,the CBR value can also be obtained by make a correction by applying the correction factor as shown in figure:(b).

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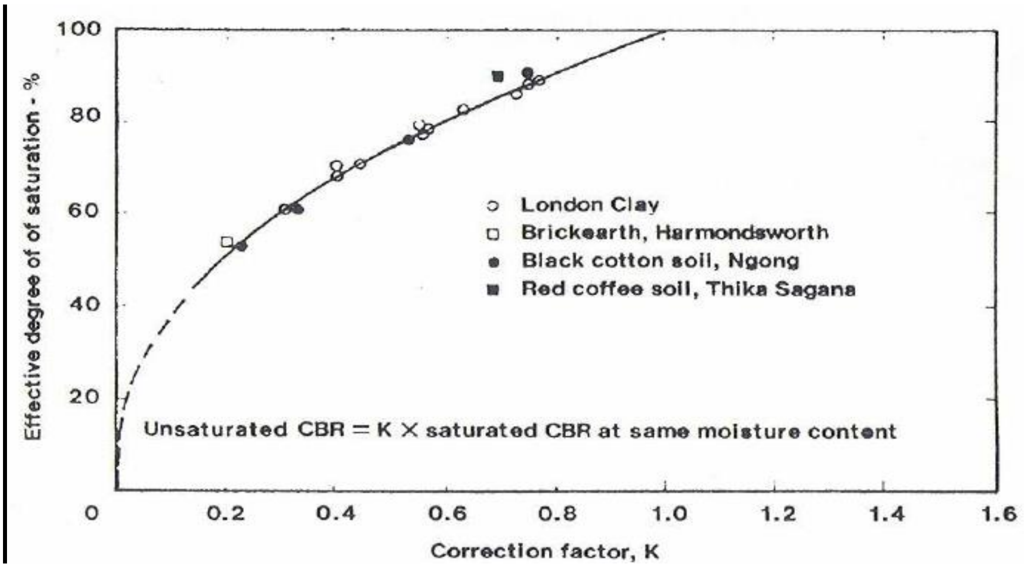

Fig:(b).Correction for CBR values for Partial Saturation Condition (Black,1962).

. The **Highway Agency (1994)** predicted different CBR values based on Plasticity Index(PI) for British Soils, compacted at natural moisture content as shown below in Table 1.

Table 1: Prediction of CBR values for different soil types

(The Highway Agency, 1994)

(The Highway Agency, 1994)

Type of Soil	Plasticity Index	Predicted CBR(%)
Heavy Clay	70 60 50 40	2 2 2 2 – 3
Silty Clay	30 20	3 - 4 4 - 5
Sandy Clay	10	4 – 5
Sand(Poorly Graded)		20
Sand(Well Graded)		40
Sandy Gravel(Well Graded)		60

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In **2001,Transportation Research Board** recommend a co relation formulae to estimate the values of Plasticity Index.

According to this formulae For materials with plasticity Index(I_p) ,greater than zero,a weighted plasticity index ,termed $I_{pw}$is used.

where,

weighted plasticity index = $I_{pw} = I_p * P_{200}$

I_p = Plasticity Index of soil in percent.

P_{200} = Percentage Passing 200 micron sieve.

Now,

when ,weighted plasticity index(I_{pw}) = 0

Then, $CBR = 28.09(D_{60})^{0.358}$

And, when soils exhibits some plasticity and containing more than 12 Percent fines(i.eI_p is greater than zero)

Then, $CBR = 75/ [1+0.728(I_{pw})]$

This equation is best suited for Lateritic soils or Laterite soils

In 1982,Doshi and Guirgui's proposed a correlation between CBR value, OMC and MDD. Their research was based on tests on different Kuwaiti soils. They suggested that:

$CBR = 187.81 – (3.12* OMC) – (69.71* MDD)$

Where,

CBR= Soaked CBR value(%).

MDD= Maximum Dry Density in gm/cm^3

OMC= Optimum Moisture Content in percent

In 2004,Shukla and Kukalyekar proposed an another correlation to predict the CBR value from Optimum Moisture Content and Maximum Dry Density . They proposed that:

$CBR_{(SOAKED)} = -2.97 – 0.1162 * OMC + 12.9853 * MDD$

$CBR_{(UNSOAKED)} = -5.71 – 0.2235 *OMC + 24.9717 *MDD$

Where,

$CBR_{(SOAKED)}$= Soaked CBR value(%).

$CBR_{(UNSOAKED)}$ = Unsoaked CBR value(%).

MDD= Maximum Dry Density in gm/cm^3

OMC= Optimum Moisture Content in percent.

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In **2006,Kin** proposed a correlation to predict soaked CBR values from Optimum Moisture Content (OMC) and Maximum Dry Density(MDD).He proposed :

$$CBR = OMC*(MDD/19.3)^{20}$$

Where,

CBR= Soaked CBR value(%).

MDD= Maximum Dry Density in kn/m^3.

OMC= Optimum Moisture Content in percent.

In 2010,.Saboo,Kalpana Rani and Bisbt indicate that, this correlation predicts very high CBR values in many cases

In **2009, Roy et. el.** Proposed an another correlation to predict the soaked CBR value from Optimum Moisture Content (OMC) and Maximum Dry Density(MDD).He proposed that :

$$Log[CBR]=Log[MDD/UNIT\ WEIGHT\ OF\ WATER] - Log[OMC]$$

Where,

CBR= Soaked CBR value(%).

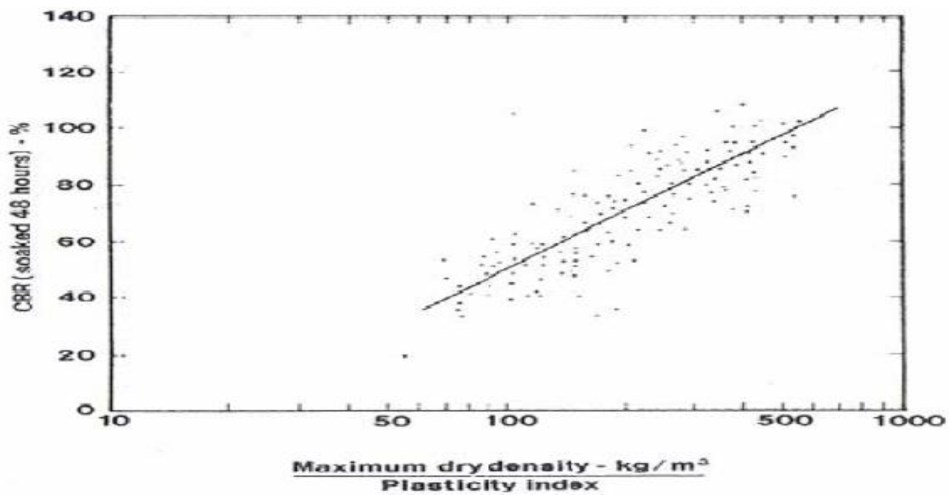
MDD= Maximum Dry Density in kn/m^3.

OMC= Optimum Moisture Content in percent

. In 2010,**Ferede**Proposed an another correlation to predict the soaked CBR value **for Granular Soils .He proposed:**

$$CBR = - 27.998 +0.029 *OMC^2 +4.796 *MDD^4$$

In **1979, De Graft-Johnson et al.** made his further research on lateritic gravel and proposed a relationship between the CBR value and the ratio of maximum dry density to the plasticity index. In Fig.(c).



Fig(c) Relationship between the ratio of maximum dry density to the plasticity index and CBR value for laterite quartz gravels.

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. In **2010, Patel&Desai**, proposed an another correlation to determine the value of soaked and unsoaked CBR For Fine Grained Soil.He proposed:

$CBR_{unsoaked}$= 17.009 - 0.0696PI - 0.296MDD + 0.0648OMC

CBR_{soaked}= 43.907-0.093PI - 18.78MDD - 0.3081OMC

Where,

$CBR_{(SOAKED)}$= Soaked CBR value(%).

$CBR_{(UNSOAKED)}$ = Unsoaked CBR value(%).

MDD= Maximum Dry Density in gm/cm^3.

OMC= Optimum Moisture Content in percent.

PI = Plasticity Index in percent.

U.C.Saboo ,M.G.Kalpana Rani and A.S.Bisbt (in2010),proposed an another correlation .They tested Thirty four different types of soil sample in the Laboratoy to evaluate different properties.

Based on these results, they made a best possible correlation. They Proposed:

CBR = 7.88*MDD – 0.17*$P_{0.075}$ – 0.07*wLL + 5.07

Where,

MDD= Maximum Dry Density in gm/cm^3.

$P_{0.075}$ = Percent Passing 75 micron IS sieve.

wLL = Weighted Liquid Limit = LL*(P_{425}/100).

$P_{0\cdot425}$ = Percent Passing 425 micron IS sieve.

The R^2 value of the above correlation is 0.91.The t-statistics values for the parameter estimates are 3.55,5.20 and 1.20 for MDD, $P_{0.075}$ and wLL. which is statistically significant.

A.In**1969, De Graft-Johnson and Bhatia** made an another research. They carried out the research by the course grained soil sample. The soil samples were collected from Ghana. They had developed a correlation of CBR with plasticity and grading using concept of suitably

index. In their research, the soil samples were compacted to maximum dry density at

the optimum moisture content and soaked for the 4 days according to Ghana

standard of compaction. They used a standard CBR mould and 4.5 kg rammer with

450 mm drop height to compact 5 layers using 25 blows per layer. The correlation

that they developed is shown in figure(d) and the Suitability index, from which the CBR value can be calculated is defined as

suitability index = A/ LL * log(PI)

where,

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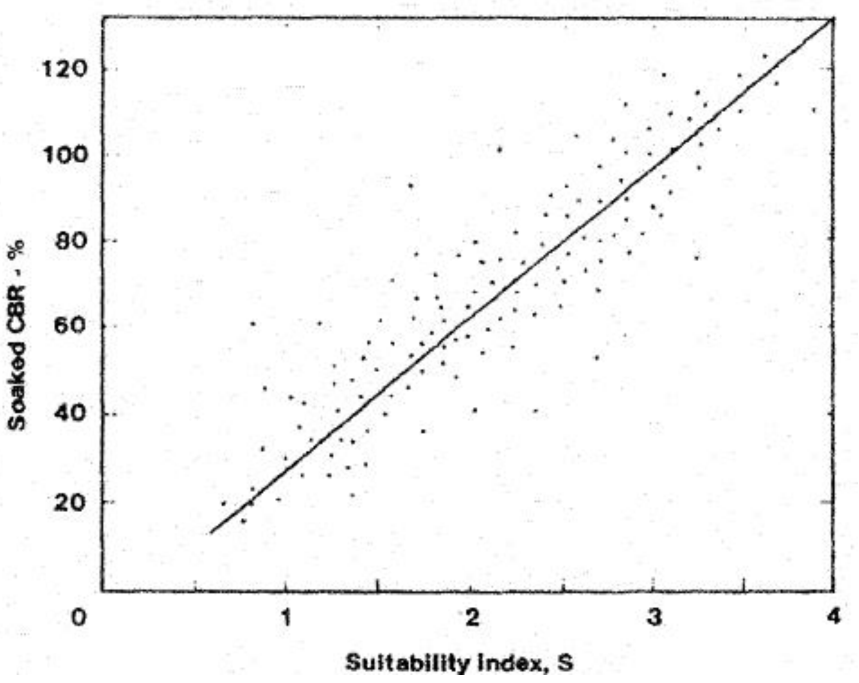
A = Percent passing 2.4inna BS sieve

BS sieve = British Standard Sieve.



Fig(d) relationship between suitability index and soaked CBR values.

In **1970,**Based on the research on 48 soil samples of fine grained soils found in India**, Agarwal and Ghanekar** had tried to develop a correlations between CBR values and either liquid limit, plastic limit or Plasticity index but could not find any significant relationship between them.However ,they found a better correlation of CBR with optimum moisture content(W_{opt}) and liquid limit (LL).They suggested that:

$$CBR = 2.0 - 16.0*\log (W_{opt}) + 0.07*LL$$

Where,

W_{opt} = Optimum moisture content in percent .

LL = Liquid limit in percent.

In 2012,SoewignjoAgus NUGROHO, Andy HENDRI and Sri Rahayu NINGSIH made their research to obtain the correlation betweenCBR soaked test and CBR un-soaked test results, comparison of two kind CBR test condition of several mixture soil samples from Pekanbaru were performed. The CBR tests of two condition tests were performed for each mix-soil sample from each variation. There were 45 CBR soaked tests and 45 CBR un-soaked tests performed of sand and clay mixture soil within the city of Pekanbaru, Indonesia. After analyzing all the results they find a correlation between CBR value and LL,PI and OMC. They suggest:

$$\Delta CBR = -25.00+C_1\,Clay-C_2\,LL-C_3PI+3.50OMC$$

Where,

ΔCBR = value of CBR $_{un\text{-}soaked}$ - CBR $_{soaked}$.

LL= Liquid Limit

PI= Plasticity Index

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OMC= Optimum Moisture Content

coefficient value of C1, C2 and C3 for different clay fraction are found from the following table:

	Value	Value	Value
Clay fraction	C1	C2	C3
Less than 30%	0.335	0.529	2.627
30 to 70	0.168	0.064	2.356
More than	0.35	0.50	2.40

A. In 2006,Satyanarayana Reddy &Pavani*proposed a correlation between CBR and* Percentage Finer , Liquid Limit and Maximum Dry Density .They proposed:

$$CBR_s=-0.388F-0.064LL+20.38MDD$$

Where,

F= Percentage of Fines (Silt+Clay)

S= Percentage of Sand

LL= Liquid Limit in percent.

PL= Plastic Limit in percent.

MDD= Maximum Dry Density in gm/cm^3

B. InYildirim&Gunaydin proposed some correlations between CBR and other parameters. They are

$$CBR = 0.2353G+3.0798$$

$$CBR=-0.1805F+18.508$$

$$CBR=0.22G+0.045S+4.739MDD+0.122OMC$$

$$CBR=0.62\,OMC+58.9\,MDD+0.11LL+0.53PL-126.18$$

Where,

CBRs = Soaked California Bearing Ratio

G=Percentage of Gravel,

F= Percentage of Fines (Silt+Clay)

S= Percentage of Sand

LL= Liquid Limit in percent.

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PL= Plastic Limit in percent.

MDD= Maximum Dry Density in gm/cm^3.

OMC= Optimum Moisture Content in percent

In 2013,*Ramasubbarao, and Siva Sankar, proposed a correlation between CBR and* grain size analysis (%Gravel, %Sand, %Fines), Plasticity Characteristics (LL, PL) and Compaction Characteristics; namely MDD and OMC which seems to be reasonable in the estimation of soaked CBR value of fine grained soils. To develop the equation, simple linear regression analysis and multiple linear regression analysis were carried out. They suggests

CBRs=0.064F+0.082S+0.033G-0.069LL+0.157PL-1.810MDD-0.061OMC

Where,

CBRs = Soaked California Bearing Ratio

G=Percentage of Gravel,

F= Percentage of Fines (Silt+Clay)

S= Percentage of Sand

LL= Liquid Limit in percent.

PL= Plastic Limit in percent.

MDD= Maximum Dry Density in gm/cm^3.

OMC= Optimum Moisture Content in percent.

. **PredictionOf CBR (Soaked) Value From IRC:Sp:72-2007**

For the design of new roads, the CBR value may be predicted as per **IRC:SP:72-2007** by using the presumptive chart on the basis of soil classification tests which gives typical presumptive design CBR values for soil samples compacted to maximum dry density at optimum moisture content and soaked under water for 4 days.

A. Typical Presumptive chart for CBR Values

Description of Subgrde Soil	IS Soil Classification	Typical Soaked CBR Values (%)
Highly Plastic Clays and Silts	CH, MH	* 2 - 3
Silty Clays and Sandy Clays	ML, MI CL, CI	4 – 5
Clayey Sands and Silty Sands	SC, SM	6 - 10

* Expansive clays like BC Soil may have a soaked CBR values of less than 2%

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Need for further Study:

From the review of literature ,it is observed that studies on the prediction of CBR value by correlating the CBR with easily determinable soil parameter have been made to some extent. Such correlation being empirical in nature, may give reliable results only for the region from which such soil data for correlation were collected. Further majority of correlation are for CBR in unsoaked condition while in design of flexible pavement, CBR value in soaked condition, are used.

Stressing on the need for alternate method for CBR test, Sikder (2003) indicated that possible variation in pavement thickness, resulting from an error in estimation of CBR value, may lead to unnecessary wastage of capital investment. Similarly the non-identification of the weak sport along the alignment of proposed road which is possible when only limited number of CBR test are conducted in conventional manner, may lead to short life of the road.

Reliability of any prediction depends primarily on the relative importance of the factor in controlling the magnitude of the output. In search of the best correlation for CBR, the most important parameter influencing the value of CBR should be identified. This was studied by Kaur et el (2011), following innovative technique proposed by Garson (1991). They have indicated that PI followed by LL are the most important factor influencing the value of CBR, other parameter like maximum dry density, fine fraction, sand fraction etc, have influence but of much lesser significance

In view of the above discussion, a study was undertaken for finding the correlation between soaked CBR value and PI and Percentage Finer of the soils from alluvial plain and validity of the correlation developed is tested by comparing the predicted value of CBR(soaked) into tested value of CBR(Soaked).For this purpose a *large number of data generated from soil exploration for design of rural roads in last few years*, under PMGSY scheme, have been collected.

Methodology Of The Research:

To develop the prediction model, data for only fine-grained soils were used. A large number of soil data are collected. All the data are divided into two parts, one part is used to develop the prediction model and another part is used to check the validity of the proposed correlations. Here the test results of Medium Plastic soil(PI value within 7 to 17) are used. Again the Medium Plastic soil are divided into CL and CI Group to find the best possible correlation and more accurate result.

For each group of soils the observed values of CBR are plotted against (W*PI) of the soil. Where W is percentage of soil passing 75µ and PI is plasticity index of soil. From the relationship the trend of variation of CBR value with the change of (W*PI) value was noted . Now, efforts are made to establish a best fit curve that can fit the point as closely as possible. The equation of best fit curve is developed for necessary co relation.

Analysis of Medium Plastic soil:

CL GROUP:

From the chosen data(W*PI) values are plotted against CBR(soaked) value to develop a best fitted curve which is shown in figure

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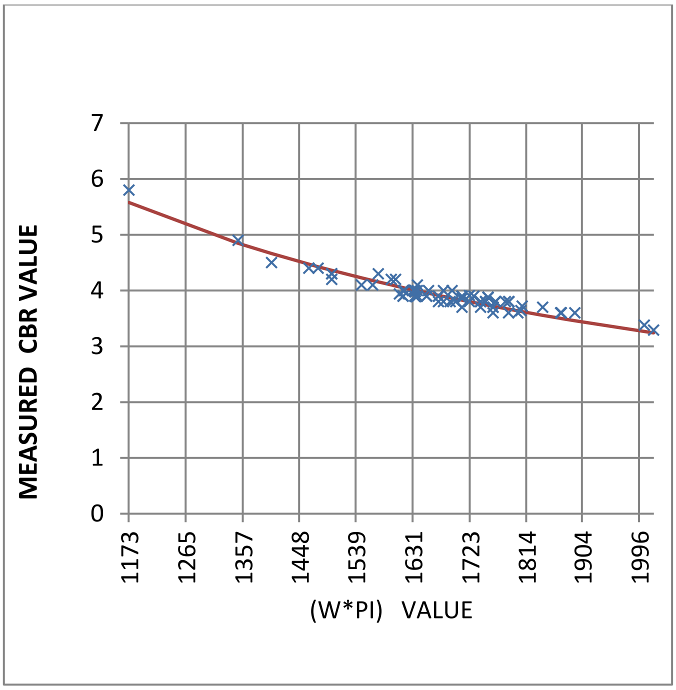
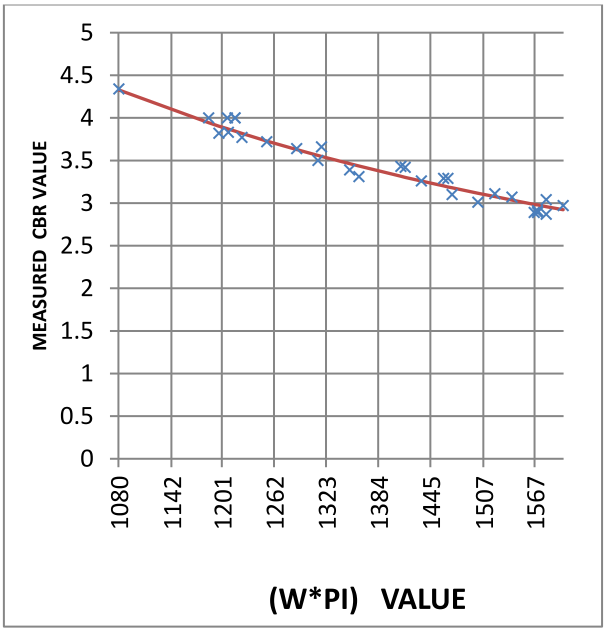


CI GROUP

From the chosen data(W*PI) values are plotted against CBR(soaked) value to develop a best fitted curve which is shown in figure



Now, from the plotted points the best fit curve is found. And the equation of the best fit curve is calculated.Tthe equation of the best fit curve

For CL Group soil, CBR(soaked)=4650/(W*PI)

For CI Group soil, CBR(soaked)=4680/(W*PI)

Checking The Validity Of The Correlation:

For CL Group soil, CBR(soaked)=4650/(W*PI)

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W	PI	LL	MEASURED CBR VALUE	PREDICTED CBR VALUE	ERROR	SOIL GROUP
88	11.5	28.8	5.1	4.59	-9.9	CL
86.5	14.3	32.2	4.17	3.76	-9.85	CL
87.6	11.5	29	5.1	4.62	-9.49	CL
90.4	13.5	34.8	4.2	3.81	-9.28	CL
61.5	14	30	5.95	5.4	-9.23	CL
80	16	30	4	3.63	-9.18	CL
94	13.4	33.2	4.05	3.69	-8.85	CL
91	14	32	4	3.65	-8.75	CL
90	14	32	4.01	3.69	-7.97	CL
85	13	30	4.57	4.21	-7.92	CL
88.4	16.3	34.4	3.5	3.23	-7.8	CL
90	14	32	4	3.69	-7.74	CL
100	14.3	33.7	3.52	3.25	-7.62	CL
73	15.3	31.8	4.49	4.16	-7.28	CL
62	16.8	28	4.8	4.46	-6.99	CL
78	16	35	4	3.73	-6.85	CL
100	11.6	32.1	4.3	4.01	-6.78	CL
89	14	35	4	3.73	-6.7	CL
80.5	11.9	28.5	5.2	4.85	-6.65	CL
66.5	14.1	29.6	5.3	4.96	-6.43	CL
74	16.3	32	4.1	3.86	-5.97	CL
71.4	16.1	34	4.3	4.05	-5.93	CL
50	13	32	7.59	7.15	-5.75	CL
90.2	12.7	34.5	4.3	4.06	-5.6	CL
100	12.1	33.5	4.05	3.84	-5.11	CL
81	15	30	4	3.83	-4.32	CL
59.4	13	28	6.28	6.02	-4.11	CL
93	13	34	4.01	3.85	-4.09	CL
90.1	13.1	34.6	4.1	3.94	-3.91	CL
88	14.5	34.3	3.5	3.64	4.12	CL
88.7	14.1	33.2	3.57	3.72	4.146	CL
71	11	23.4	5.7	5.95	4.454	CL
74	15	32	4	4.19	4.73	CL
90	13	32	3.79	3.97	4.864	CL
85	13	35	4	4.21	5.204	CL
90	12	30	4.08	4.31	5.528	CL
89	13	32	3.8	4.02	5.764	CL
64	11.4	24.3	6.02	6.37	5.87	CL
89	13	31	3.79	4.02	6.043	CL

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89.79	13.48	30.7	3.62	3.84	6.127	CL
88.7	14	33.1	3.52	3.74	6.38	CL
84.6	9.39	22.3	5.49	5.85	6.621	CL
79	14	34.5	3.94	4.2	6.709	CL
72	11	31	5.5	5.87	6.749	CL
67	10.6	20.1	6.1	6.55	7.335	CL
72	15	32	4	4.31	7.639	CL
87.2	9.97	21.2	4.96	5.35	7.835	CL
71	10.6	23.2	5.7	6.18	8.396	CL
88.8	9.23	22	5.23	5.67	8.477	CL
89	12	35	4	4.35	8.848	CL
85	12	30	4.18	4.56	9.063	CL
73.3	8.8	25	6.6	7.21	9.225	CL
85.7	9.08	21.3	5.47	5.98	9.244	CL
94	15	32	3	3.3	9.929	CL

For CI Group soil, CBR(soaked)=4680/(W*PI)

W	**PI**	**LL**	**MEASURED CBR**	**PREDICTED CBR**	**ERROR**	**GROUP**
94	16	36	3.5	3.11	-11.09	CI
89.9	16.8	37	3.48	3.1	-10.96	CI
89.9	17	36.8	3.43	3.06	-10.72	CI
77	17	36	4	3.58	-10.62	CI
76.4	16.3	35.3	4.2	3.76	-10.52	CI
87.9	16.5	41.9	3.6	3.23	-10.37	CI
100	16	38.5	3.26	2.93	-10.28	CI
87.7	16.4	41.8	3.62	3.25	-10.11	CI
92.7	17	41	3.3	2.97	-10.01	CI
87.3	16.3	41.6	3.63	3.29	-9.398	CI
92	13.4	36.1	4.18	3.8	-9.181	CI
82.1	16	42	3.9	3.56	-8.648	CI
100	17	47.8	3.01	2.75	-8.54	CI
87.9	16	41.9	3.63	3.33	-8.329	CI
100	15.7	38.6	3.25	2.98	-8.28	CI
83	15.6	36.5	3.94	3.61	-8.262	CI
83	15.6	36.5	3.94	3.61	-8.262	CI
87.2	15.9	41.2	3.66	3.38	-7.774	CI
100	16.8	40.1	3.02	2.79	-7.758	CI
93.2	17	42	3.2	2.95	-7.694	CI
87.1	15.8	41.2	3.68	3.4	-7.589	CI

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90	14	36	4	3.71	-7.143	CI
92	15	37	3.64	3.39	-6.832	CI
100	15.4	40.2	3.21	3.04	-5.328	CI
70.7	16.9	38.5	4.13	3.92	-5.16	CI
88.7	17	42.4	3.25	3.1	-4.503	CI
100	15.9	36.3	3.08	2.94	-4.435	CI
100	14.3	39.6	3.08	3.27	6.257	CI
74.8	16.9	38.8	3.48	3.7	6.384	CI
74.1	16.9	39.5	3.49	3.74	7.082	CI
74.1	16.9	39.5	3.49	3.74	7.082	CI
96	15.1	35.7	3.01	3.23	7.258	CI
100	14	43.8	3.11	3.34	7.487	CI
96.3	13.6	39.7	3.29	3.57	8.614	CI
100	15.3	42.7	2.81	3.06	8.855	CI
72.9	16.4	40.7	3.57	3.91	9.649	CI
74.5	17	40.7	3.37	3.7	9.651	CI
73.3	15.9	40.6	3.66	4.02	9.714	CI
74	15.5	40.3	3.69	4.08	10.57	CI
94.9	15.4	38.6	3.07	3.2	4.309	CI
76.6	15.9	39.9	3.68	3.84	4.417	CI
100	15.4	43.9	2.91	3.04	4.432	CI
100	10.8	35.3	4.14	4.33	4.67	CI
100	13	35.3	3.43	3.6	4.956	CI
69.4	16	39	4	4.21	5.367	CI
72.2	16.9	40.5	3.64	3.84	5.371	CI
73.4	17	40.6	3.55	3.75	5.651	CI
69.1	15.9	38.1	4.03	4.26	5.698	CI
71.3	16.8	39.9	3.69	3.91	5.882	CI
100	13.6	41.3	3.25	3.44	5.882	CI
83.3	14.1	41.6	3.6	3.98	10.68	CI
98.8	14.3	41.4	2.99	3.31	10.79	CI
88	12	36	4	4.43	10.8	CI
78.3	15.9	41.2	3.39	3.76	10.89	CI

CONCLUSION:

Considering the CBR value test of soil is laborious and time consuming, it can be emphasized that the use of other properties for estimating CBR value such as Liquid Limit, Plastic Limit, Grain size analysis which is obtained from low cost and less time consuming test can be used. In the present study a new correlations have been proposed for predicting the CBR value from Percentage Finer (75 micron) and Plasticity Index.

The proposed correlation is **:**

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CBR(soaked)= X / (W*PI)

Where, W= Percentage Finer through 75 micron

PI = Plasticity Index

And the values of X are different for different groups of soil which are given below

For , CL Group soil, The value of X = 4650 and

For , CI Group soil, The value of X = 4680

Here, it is observed that the predicted values of CBR are closer to the measured values of CBR. This model predicts the soaked CBR values from grain size analysis and PI Value of soil. This will be help full for Geotechnical Engineer to predict the soaked CBR value and also will be helpful for checking the reliability of laboratory tested CBR value.

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