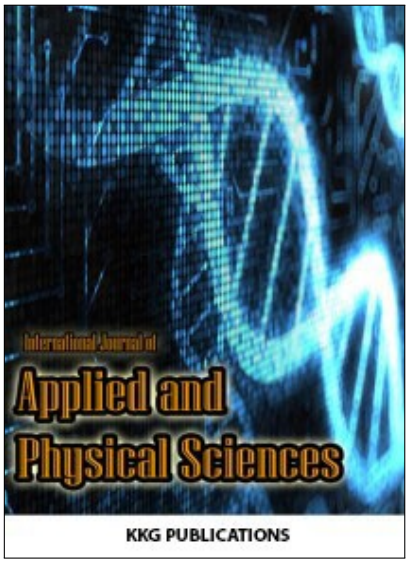


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# STATISTICAL ANALYSIS OF STRENGTH PROPERTY OF SOIL

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**Abstract**. Soil properties like California Bearing Ratio (CBR) and bearing capacity are very important for every civil infrastructure work. These properties are often required for construction works. But the procedure for finding these properties is very tedious and lengthy. It consumes a lot of time and money to obtain these results. Therefore, an attempt is made to find an alternate method for finding these properties using other properties requiring less resource. CBR is a commonly used indirect method to assess the stiffness modulus and shear strength of subgrade in pavement design. However, it is always difficult for transportation engineers to obtain representative CBR values for pavement design. The soil type is not the only parameter that affects the CBR value, but it also varies with different soil properties possessed by the soil. Various researchers have performed CBR and other soil tests to get the behavior and find the design parameters. However, few studies have been done to perform the regression analysis. Through regression analysis, one can have the trend of the dependent parameters with other independent parameters. To study the same, a method is proposed for correlating CBR values with the Liquid Limit, Plastic Limit, Plasticity Index, Optimum Moisture Content, and Maximum Dry Density of black cotton soils mixing with admixtures. The correlation is established in the form of an equation of CBR as a function of different soil properties by regression analysis. Comparison is done between the experimental results and calculated results. Statistical Analysis was carried out using SPSS Software version 10.



## INTRODUCTION

Development of any region depends on its infrastructure development. Identification of soil behavior and strength properties plays a vital role in the infrastructure development. Soil properties such as California Bearing Ratio (CBR) play a vital role for defining the strength parameters of soil in various civil construction works such as highway and railway network. For the construction of good quality roads and other structure high strength of soil is desirable.

Moreover, nowadays it is not possible to find perfect quality of soil at desired site. Sometimes, it is required to enhance by mixing with admixtures or locally available suitable materials such as fly ash and rice husk ash.

To get the optimum quantity of admixture it becomes necessary to find the CBR of soil at different proportions of admixture.

Various researchers [1], [2], [3], [4], [7], [8] have determined optimum amount of different locally available materials i.e., rice husk ash, fly ash, and granulated blast furnace slag. The procedure for determining these properties is very time consuming and requires a considerable amount of resources [9], [10]. These soil properties vary with different soil index properties. However, by using software like SPSS these values can easily be determined with the help of index properties.

Determination of CBR at various blend ratios requires a lot of time and labor, whereas other soil properties like specific gravity, optimum moisture content, maximum dry density, index properties etc. can be easily determined in relatively very less time. In this paper an attempt has been made to correlate the CBR with soil properties by regression analysis. It can be the alternate method for the time consuming tests. These tests are much economical and rapid than CBR test.

## LITERATURE REVIEW

Few studies have already been conducted using SPSS software for correlation of CBR with index properties of soil. The study of [5] "CBR Predicted by index properties of Alluvial Soils of South Gujarat" is taken as the base for this study. In this study CBR for alluvial soils of south Gujarat are correlated with the index properties of the soils. Correlation equations are found using SPSS software. To verify the methodology used, the data from this study are taken and relation between CBR and soil index properties has been found using SPSS 10.0 and checked with the literature. The equations obtained by regression analysis are matching closely with [5].

## METHODOLOGY

Available experimental data have been taken from various places of soil of Chhattisgarh, India region and these

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data have been analyzed for regression analysis using SPSS version 10 software. To fulfill the objective of the study, the data collected were studied and were analyzed statistically. To build the relation between California Bearing Ratio and the soil index properties linear regression model is used through SPSS software.

Following procedure has been used for statistical analysis:

- Variable names and properties were entered using left bottom tab of SPSS start window. First variable name has to be entered in the variable view and then properties may be entered in the corresponding variable view.
- Switch back to data view and enter the data.
- In the top menu it is required to go to 'analyze regression linear'. A pop-up window appears. Here it is required to provide the dependent variable (CBR) and independent variables, and click on ok.
- Reading output result and the coefficients of the equation are shown in the coefficients table under the column B.

To verify the procedure the data of [5] have been taken and equations were obtained using linear regression. Table 1 shows the equations developed and error obtained from the study of [5]. The correlation equations are matching with acceptable errors of the equations of [5]. This verifies the procedure used in this study.

TABLE 1
EQUATIONS DEVELOPED AND ERROR

| Eq.No | PRAMETERS USED | Equation found CBR = | %error in estimation |
|---|---|---|---|
| 1 | LL, PL, SL, MDD | 64.516 - 0.28LL + 0.273PL - 0.408SL-25.792MDD | 14.3% |
| 2 | LL, PL, SL | 11.825 - 0.127LL + 0.2205PL - 02.2447SL | 25% |
| 3 | LL, PL | 4.745 - .044LL + 0.151PL | 23.5% |

## RESULTS AND DISCUSSION

Data set was taken from [6]. In this study soil sample has been obtained from Tatibandh-Atari Road of Raipur district, Chhattisgarh. Table 2 shows the properties of the soil as data set. In this study RHA has been used as admixture for improvement of the poor soil for enhancing its CBR.

TABLE 2
PROPERTIES OF SOIL AS DATA SET FOR CORRELATION

| RHA | GS | MDD | OMC | LL | PL | 1p | CBR |
|---|---|---|---|---|---|---|---|
| 0 | 2.63 | 1.9 | 11.86 | 47 | 30 | 17 | 4.08 |
| 3 | 2.57 | 1.83 | 12.92 | 47.85 | 33.29 | 14.56 | 5.26 |
| 6 | 2.518 | 1.78 | 14.83 | 49 | 39 | 10 | 7.13 |
| 9 | 2.509 | 1.75 | 15.96 | 50.64 | 41.4 | 9.24 | 8.23 |
| 11 | 2.475 | 1.72 | 16.63 | 51.12 | 42.22 | 8.9 | 11.83 |
| 13 | 2.45 | 1.69 | 17.24 | 51.87 | 45.47 | 6.39 | 9.55 |
| 15 | 2.43 | 1.63 | 19.43 | 54.46 | 48.41 | 6.05 | 9.41 |

Table 3 shows the result of regression analysis showing coefficients of equation 1 for the used data set. Table 4 presents the result of regression analysis showing coefficients of equation 5. Equations and percentage error of data set are shown in Table 5. Comparison between observed and predicted values is shown in Fig. 1. It can be clearly seen from the above graph that CBR value found by equation 1 and that by equation 5 are similar to the actual observed values. It is to be noted that these two equations are the equations where all the parameters are taken for regression. Equation 1 has been formed by simple linear regression giving the better result than equation 5 formed using log of variables.

TABLE 3
RESULT OF REGRESSION ANALYSIS SHOWING COEFFICIENTS OF EQUATION 1

Coefficients[3]

| Model | Unstandardized Coefficients B | Std. Error | Standardized Coefficients Beta | t | Sig. |
|---|---|---|---|---|---|
| 1 (Constant) | 114.556 | .000 | | | |
| LL | -8.146 | 0 | -7.798 | | |
| OMC | 7.857 | .000 | 7.632 | | |
| RHA | 2.339 | .000 | 4.760 | | |
| SOS | 69.526 | .000 | 1.820 | | |
| MDD | -17.731 | .000 | -.597 | | |
| IP | 1.767 | .000 | 2.698 | | |

a. Dependent Variable: CBR

TABLE 4
RESULT OF REGRESSION ANALYSIS SHOWING COEFFICIENTS OF EQUATION 5

| Model | Unstandardized Coefficients B | Std. Error | Standardized Coefficients Beta | t | Sig. |
|---|---|---|---|---|---|
| 1 (Constant) | -14.934 | 4.961 | | -3.010 | 0.204 |
| LOGGS | -69.983 | 8.900 | -5.214 | -7.863 | 0.81 |
| LOGMDD | 42.930 | 6.122 | 5.893 | 7.013 | .090 |
| LOGOMC | 1.737 | 1.018 | .799 | 1.706 | 0.338 |
| LOGLL | 17.495 | 4.285 | 2.385 | 4.083 | 0.153 |
| LOGIP | 1.505 | 0.211 | 2.561 | 7.136 | 0.089 |

a. Dependent Variable: LOGCBR

TABLE 5
EQUATIONS AND PERCENTAGE ERROR OF USED DATA SET

| Eq.No | PRAMETERS USED | Equation found CBR = | %error in estimation |
|---|---|---|---|
| 1 | Gs, LL, PL, Ip, MDD, OMC | 114.556 - 8.146LL + 7.857OMC + 2.339RHA +69.526Gs - 17.731Ip | 0.14% |
| 2 | LL, PL, MDD, OMC | 148.607 - 16.616MDD + 4.987OMC - 3.283LL - 0.6PL | 10.17% |
| 3 | Ip, MDD, OMC | 19.212 .371 Ip - 5.296MDD + 0.1180MC | 9.37% |
| 4 | RHA, Gs, MDD, OMC | -0.533 + 0.779RHA - 76.747Gs + 103.801MDD + 0.8030MC | 7.37% |
| 5 | Log(Gs), log(MDD), log(OMC), log(LL), Iog(Ip) | Log(CBR) = - 14.934 - 69.9831og(Gs) + 42.930log(MDD) + 1.737log(OMC) + 17.4951og(LL)+ 1.5051og(Ip) $CBR = 10^{-14.934}Gs^{-69.983}MDD^{42.93}OMC^{1.737}LL^{17.495}Ip^{1.505}$ | 2.02% |

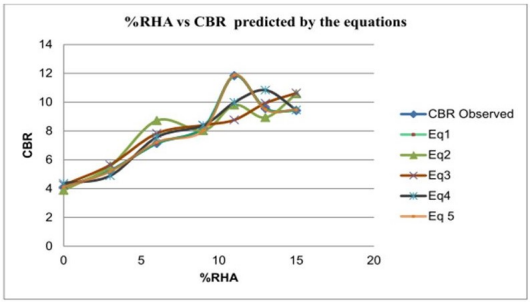


Fig. 1. Comparison between observed and predicted values data set

## CONCLUSION

Following conclusion can be made for the analysis:

- The collected data have been analyzed using SPSS and correlation between CBR and Index properties is established successfully.
- CBR values are predicted by using SPSS and accuracy is achieved so as to have a standard error as low as up to 0.014
- The value of CBR has little influence of liquid limit and

plastic limit. The value of CBR is found to decrease with increase in the plastic limit.

- Standard error in determining unsoaked CBR is found to be lesser than in determining soaked CBR.

In this study, linear regression is used to establish correlation between CBR and index properties of soil, other methods of regression analysis like nonlinear regression etc. can be used for further study.

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— This article does not have any appendix. —