# COMPARISON OF SHEAR STRENGTH PARAMETERS OF BLACK COTTON SOIL WITH EFFECT OF RELATIVE COMPACTION

**Prof. Usha k. Patel**

Assistant Professor, LDCE

**Prof. M. G. Vanza**

Associate Professor, LDCE

## Abstract

*In this paper the shear strength parameters of Highly cohesive soils is discussed. A comparison of shear strength parameters is presented between the direct shear test and UU _triaxial compression test based on relative compaction. Most of the engineering design methods and parameters of structure on soil have been developed for ideal soil, such as expansive clay which mostly deviates from the reality by atmospheric changes. In Bharuch region of Gujarat mostly Black cotton soil is available which are one of the expands during the rainy seasons and shrinks during the summer seasons . In this paper the shear strength characteristics of Black cotton soil from Bharuch region of Gujarat were performing the Direct shear test and triaxial compression test on compacted specimens based on different range of relative compaction. Shear strength parameters were determined for different relative compaction of 90%,92.5%, 95%,97.5% and 100%. From experimental investigation Black cotton soil for different relative compaction increases the cohesion and decreases the friction angle .*

***Keywords**: Black cotton soil, Relative compaction, Direct shear test, UU Triaxial test.*

## I. INTRODUCTION

Shear strength of soil is the most important properties to describe the strength of a soil material and component, against the type of yield and structural failure where material and component fails in shear. The shear strength parameter of black cotton soil is required to addressing numerous practical problems, such as slope stability of black cotton soil slopes, design of foundation of heavy structures, and construction of earth embankments on black cotton soil. Black cotton soil is highly plastic clays may derive their shear strength from the adhesion between soil particles or cohesion. In this work the sample of black cotton soil from Bharuch region were taken for the research work to study the shear strength characteristics of soil with different relative compaction which is required in the civil engineering works on black cotton soil. Review of the technical literature revealed that limited studies investigated the shear strength behavior of black cotton soils with different relative compaction. The relationship between shear strength parameters and relative compaction is obtained by laboratory test results on direct shear test and UU Triaxial test.

## II. LABORATORY INVESTIGATION

For the present work soil sample for experiments is collected from Bharuch region of Gujarat. The particle size analysis is found by wet analysis, Hydrometer test and sieve analysis of soil as per IS code 2720 (Part 4) in the laboratory is performed. The Index properties of soil is found as per IS code 2720 (Part 5). Summary of soil characterization data of black cotton soil is presented in Table-1. On the basis of the results the soil is classified as CH as per Indian standard classification of soil. The standard proctor test as per IS code 2720 (Part 7) is carried out to find the MDD and OMC of soil. Considering the maximum dry density is the density obtained with relative compaction of 100 % . For different relative compaction 90%,

92.5%, 95%, 97.5% the moisture content are evaluated from compaction curve and shear parameters are evaluated by direct shear test and UU Triaxial test.

.

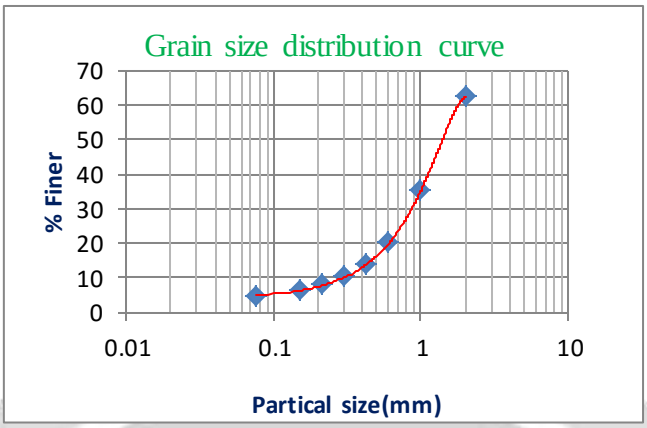


**Fig.1 Grain size distribution**

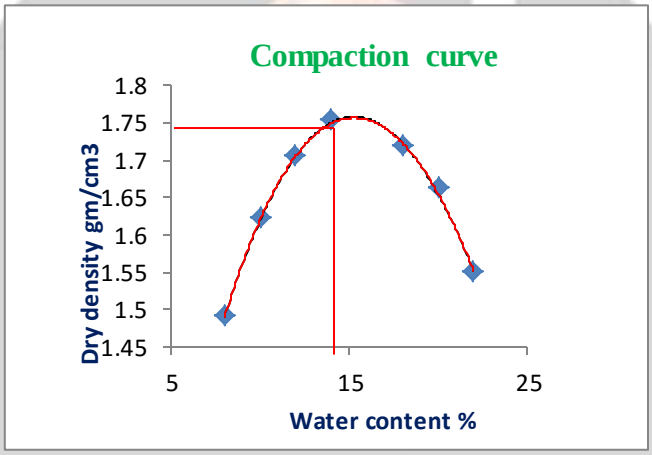


**Fig.2 Compaction curve**

**Table-1 Summary of soil characterization data**

| Characteristics | Value |
|---|---|
| Specific Gravity | 2.66 |
| Liquid limit | 69.88% |
| Plastic limit | 21.6 % |
| Plasticits Index | 48.266 % |
| Unified soil classification | CH |
| Swelling potential | 90 - 120% |
| compaction results optimum moisture content(OMC) | 14.22 % |

| | |
|---|---|
| maximum dry density MDD | 1.75 kN/$m^3$ |

**Table 2 Relative compaction**

| **Relative compaction (Rc) %** | **Maximum dry density** kN/$m^3$ | **Moisture content (W) %** |
|---|---|---|
| 90 | 1.58 | 9.20 |
| 92.5 | 1.62 | 10.00 |
| 95 | 1.66 | 11.32 |
| 97.5 | 1.70 | 12.50 |
| 100 | 1.75 | 14.22 |

## III. TESTING METHODOLOGY

### A. Sample preparation

The soil used in this study was air-dried, pulverized and sieved over sieve No.4.75 mm to remove oversized material. Remolded samples were prepared by standard proctor test results and from compaction curve of MDD and OMC. All samples are prepared by considering MDD is as 100% compaction and with different range of relative compaction 90%,92.5%,95%,97.5% and 100% at related water content.

**For Direct shear test**

- To compact Black cotton soil (CH type) at moisture content of 14.22% and dry density of 1.753 kN/$m^3$ for relative compaction of 100% .
- Preparation of samples by different relative compaction 90%,92.5%,95%,97.5% and 100%..
- Testing to be conducted on prepared samples with help of Direct shear test apparatus for normal stresses of 21.80 kN/$m^2$, 32.70 kN/$m^2$, 43.6 kN/$m^2$ and 54.50 kN/$m^2$ at constant rate of strain and measure failure of soil.
- Measurement of shear stresses and strain with proving ring and dial gauge, plotting the graphs and evaluating shear parameters..

**For UU Triaxial test**

- To compact Black cotton soil (CH type) at moisture content of 14.22% and dry density of 1.753 kN/$m^3$ for relative compaction of 100% .
- Preparation of samples by different relative compaction 90%,92.5%,95%,97.5% and 100%..

- Testing to be conducted on prepared samples with help of UU Triaxial test apparatus for confining pressure of 34.47 $kN/m^2$, 64.94 $kN/m^2$ and 103.50 $kN/m^2$ at constant and measure the deviator stress at failure of sample.
- Measurement of deviator stresses and strain with proving ring and dial gauge, plotting the Mohr circle graphs and evaluating shear parameters..

**Fig.-3 Tested soil sample of DST ( Rc 90% )**

**Fig.-4 Tested soil sample of UU ( Rc 90% )**

## IV. RESULTS AND DISCUSSION

From the Direct shear test and UU Triaxial test results we have plotting the graphs for the determination of shear strength parameters C and Φ with different relative compaction 90%,92.5%,95%,97.5% and 100% of related water content.. For Direct shear test the soil sample is remolded at different relative compaction and used for testing. All test samples were sheared under undrained condition with different stress of 21.8 $kN/m^2$,32.7 $kN/m^2$,43.6 $kN/m^2$ and 54.5 $kN/m^2$ for constant strain rate operated manually. Three samples for each relative compaction are tested on unconsolidated undrained triaxial test for different relative compaction are carried out at different cell pressures 34.47 $kN/m^2$ , 68.94 $kN/m^2$ and 103.41 $kN/m^2$. From relative compaction effect the shear strength parameters for each relative compaction is tabulated in below table. In Black cotton soil for different relative compaction also increases the cohesion and decreases the friction angle. For such cases, the foundations can be designed as C - Ø soils using the appropriate bearing capacity equations.

**Table-3 C-Φ Parameters by Direct shear test**

| Relative compaction (RC) % | Cohesion C kN/m² | Angle of internal friction Φ° |
|---|---|---|
| 90 | 20.31 | 23.21 |
| | 20.68 | 22.92 |
| | 20.94 | 22.75 |
| 92.5 | 21.53 | 22.92 |
| | 22.41 | 21.72 |
| | 22.67 | 21.32 |
| 95 | 25.71 | 19.20 |
| | 26.34 | 18.22 |
| | 26.34 | 18.17 |
| 97.5 | 26.93 | 18.45 |
| | 27.87 | 18.11 |
| | 28.27 | 16.85 |
| 100 | 27.51 | 18.91 |
| | 29.18 | 16.96 |
| | 30.18 | 15.64 |

**Table-4 C-Φ Parameters by UU Triaxial test**

| Relative compaction % (Rc) | Cohesion C kN/m² | Angle of internal friction Φ° |
|---|---|---|
| 90 | 20.00 | 19.00 |
| | 21.00 | 18.38 |
| | 21.23 | 18.25 |
| 92.5 | 21.67 | 18.00 |
| | 22.53 | 17.96 |
| | 22.96 | 17.57 |
| 95 | 22.89 | 18.21 |
| | 23.36 | 17.42 |
| | 23.52 | 17.20 |
| 97.5 | 24.50 | 18.06 |
| | 24.66 | 17.75 |
| | 25.13 | 17.52 |
| 100 | 24.93 | 16.78 |
| | 25.51 | 16.25 |
| | 25.66 | 16.00 |

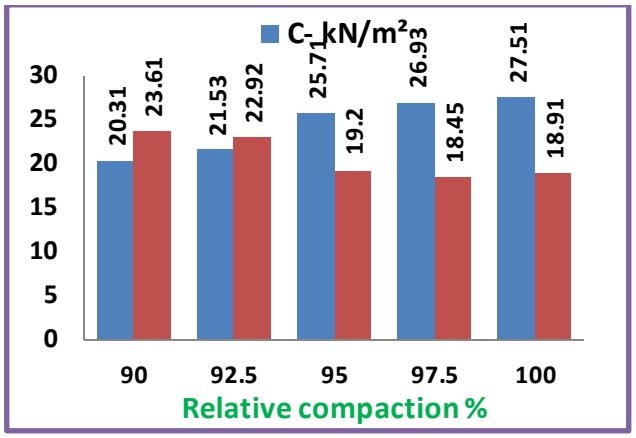


Fig.-5 C-Φ Parameters (DST) trial-1

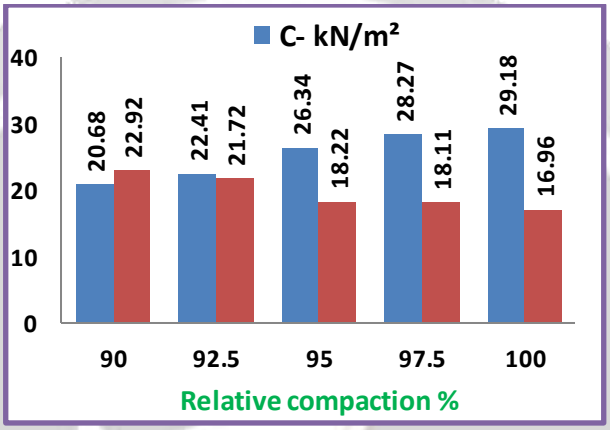


Fig.-6 C-Φ Parameters (DST) trial-2

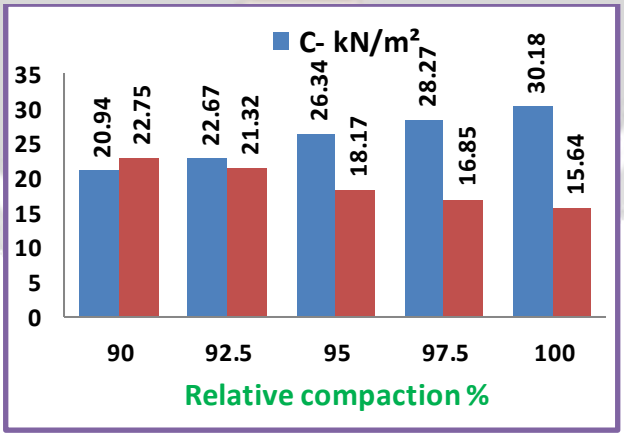


Fig.-7 C-Φ Parameters (DST) trial-3

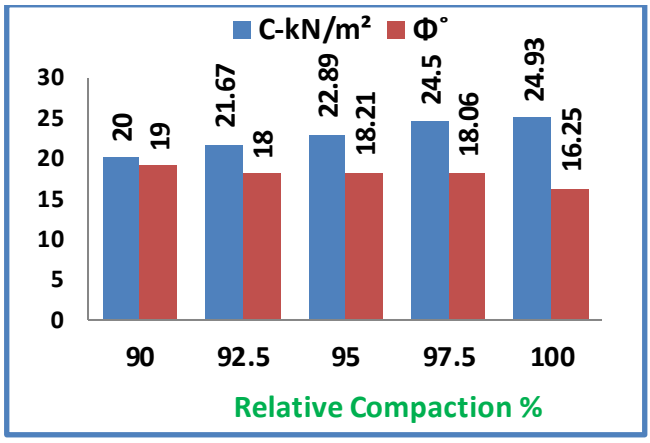


**Fig.-8 C-Φ Parameters (UU) trial-1**

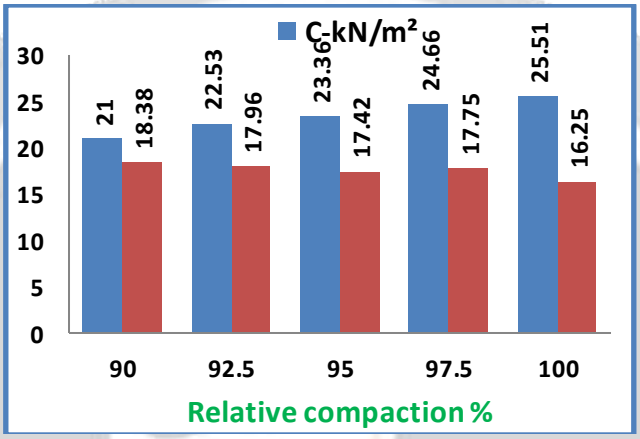


**Fig.-9 C-Φ Parameters (UU) trial-2**

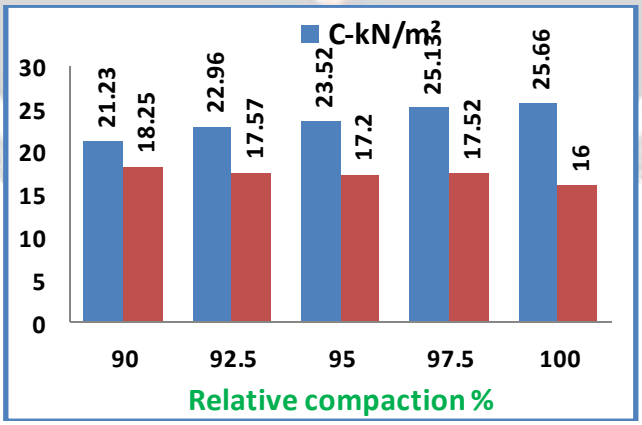


**Fig.-10 C-Φ Parameters (UU) trial-3**

## CONCLUSION

The relation from graphs indicates a strong relation between the relative compaction and shear strength parameters. The influence depends on the amount of the compaction of soil. A laboratory testing program was carried out to determine the effect of relative compaction on the shear strength parameters of black cotton soil. Unconsolidated undrained triaxial

tests were carried out on compacted sample at different relative compaction. The following conclusions can be made based on the results obtained:

1. From the test results it can be concluded that the shear strength parameters measured with Direct shear test are slightly higher than measured with UU triaxial test.

2. From the test results It can be concluded that the cohesion obtained from Direct shear test were 2 to 4 kN/m² higher than UU triaxial test.

3. From the test results It can be concluded that the friction angle obtained from Direct shear test were 2 to 4 degree higher than UU triaxial test.

**REFERENCES**

[1] Bodat Anjana R., Prof. M.G. Vanza,2015 "Effect of Relative Compaction on Shear Strength Parameters of Clayey Soil of Sabarkantha Region of Gujarat." Vol. 3, Issue 02, 2015 / ISSN (online): 2321-0613

[2] Castellanos B.A., Brandon T.L.2013 "A Comparison Between the Shear Strength Measured with Direct Shear and Triaxial Devices on Undisturbed and Remolded Soils" Proceeding of the 18th international Conference on Soil mechanics and Geotechnical Engineering, Paris 2013.

[3] Handbook for un-drained un-consolidation Tri- axial test.

[4] IS 2720 (Part 4)-1985 "Grain size analysis".

[5] IS 2720 (part 5)-1985 "Determination of liquid and plastic limit",

[6] IS 2720 (part7)-1980"Determination of water content-dry density relation using light compaction".

[7] IS 2720 (part 11)-1993 "Determination of the shear strength parameters of a specimen tested in unconsolidated undrained Triaxial compression without the measurement of pore water pressure.

[8] Kiran kumar, S.V. Biradar , Nagraj Bacha "Compaction and Strength Characteristics of Black Cotton Soil In The Presence of Hydroxides" International Journal for scientific Research and Development.

[9] NPTEL-Civil-Geo-environmental engineering.

[10] Sadanand Ojha, Asutosh Trivedi , "Shear Strength Parameters for Silty Sand Using Relative Compaction" (IJERA) ISSN: 2248-9622 Vol. 1, Issue 3, pp.1026-1033

[11] T. Y. Elkady and M.F.Abbas , 2012 "Shear Strength Behavior of Highly Expansive Soil" Geo Congress 2012 © ASCE.