Effect of Relative Compaction on Shear Strength Parameters of Black Cotton Soil Using Direct Shear Test

Smt. Usha k. Patel[1] Prof. M. G. Vanza[2]
[1]P.G Student [2]Associate Professor
[1,2]LDCE

Abstract— Black Cotton soils are characterized by high swelling and shrinkage properties , it results natural soil has many cracks and fissure, Whereas no cracks appear in compacted specimen. Therefore the study of effect of compaction on shear strength parameters of black cotton soil is required useful for the structure design. In this work a series of direct shear tests were performed on remolded samples of black cotton soil taken from Bharuch region of Gujarat, to determine shear strength parameters 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.

Key words: Black cotton soil, Relative compaction, Direct shear test

I. INTRODUCTION

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. 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. 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.

Generally geotechnical engineers face practical concerns, like the availability of good quality backfill materials and the construction costs in meeting, these criteria in the process it was aimed to observe shear strength behavior of 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. The direct shear test have been used for over many years to determined undrained shear strength parameters of soils.

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.

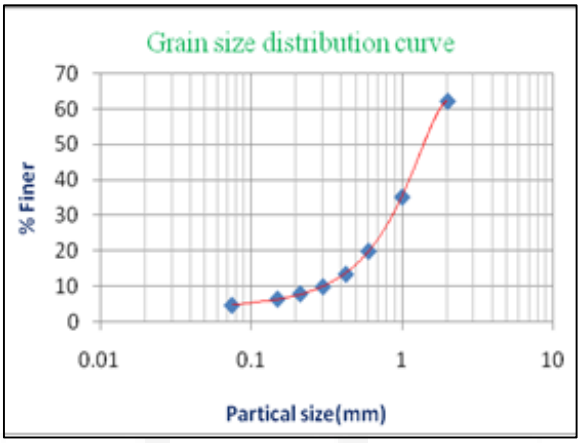

Fig. 1: Grain size distribution

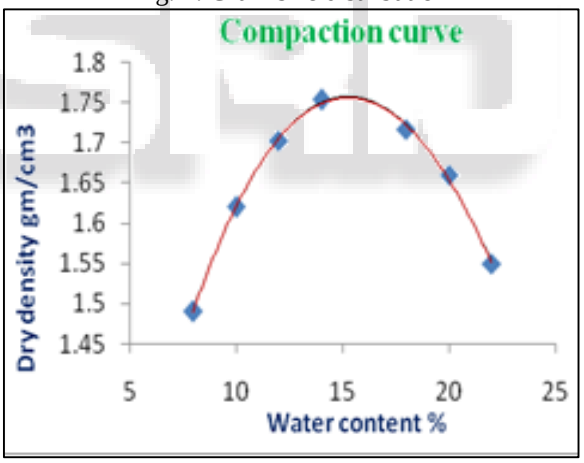

Fig. 2: Compaction curve

Fig. 3: Sieving of wet sample

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) maximum dry density MDD	14.22 % 1.75 kN/m^3

Table 1: Summary of soil characterization data

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.\

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

Table 2: Relative compaction

Relative compaction (Rc)%	Normal stress (N) kN/m²	Shear stress (S) kN/m²	Shear Parameters	
			Cohesion (C) kN/m²	Angle of internal friction (ϕ˚)
90	21.8	28.66	20.31	23.21
	32.7	33.89		
	43.6	38.78		
	54.5	41.75		
92.5	21.8	30.21	22.41	21.72
	32.7	35.32		
	43.6	39.35		
	54.5	42.65		
95	21.8	32.65	26.34	18.22
	32.7	37.58		
	43.6	40.32		
	54.5	43.27		
97.5	21.8	34.12	28.27	16.85
	32.7	38.66		
	43.6	41.36		
	54.5	43.93		
100	21.8	35.83	30.18	15.64
	32.7	39.63		
	43.6	42.11		
	54.5	44.95		

Table 3: Relative compaction

B. Test Procedure:

Direct shear tests conducted on prepared samples for strained controlled undrained test with different four normal stress for each three samples. Normal stress considered for this study ranged from(21.8 KPa to 54.5 KPa). 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/m2,32.7 kN/m2,43.6 kN/m2 and 54.5 kN/m2 for constant strain rate operated manually. For undrained tests metal plates and solid metal grilles may be used. The usual plan size of the specimen is 360 mm². The shearing Force is measured with the aid of proving-ring and displacement is measured by dial gauge. The failure plane is predetermined as the horizontal plane. Several specimens are tested under different normal load and the results plotted to obtain shear parameters C and ϕ.

Fig. 4: Tested soil sample of Rc 90%

IV. RESULTS AND DISCUSSION

From the direct shear test results we have plotting the graphs of Normal stress and shear stress 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. The relative compaction effect on shear strength parameters is as shown in Fig-5. 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.

Relative compaction (Rc) %	Cohesion (C) kN/m^2	Angle of internal friction (Φ) ˚
90	20.31	23.21
92.5	22.41	21.72
95	26.34	18.17
97.5	28.27	16.85
100	30.18	15.64

Table 4: Obtained C-Φ Parameters

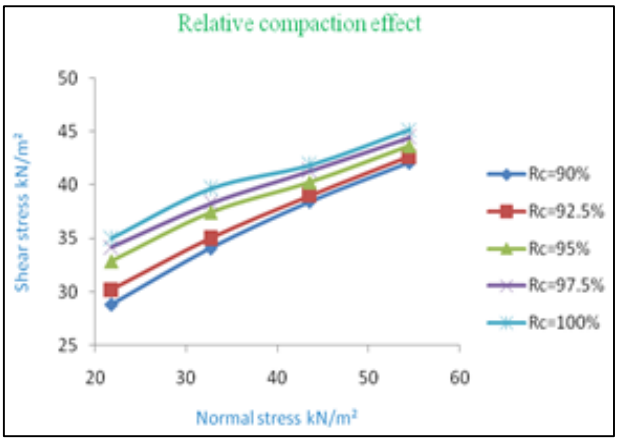

Fig. 5: Relative compaction effect

With this in view, efforts have been made in the present study to study the effects of relative compaction of shear strength parameters on the behavior of shear strength of black cotton soil and determining the effect on the compaction of the soil. Such a study would be handy to understand the deviation of the properties due to structural change in the soil. Review of the technical literature revealed that limited studies investigated the shear strength behavior of black cotton soils. The relationship between shear strength parameters and relative compaction is obtained by laboratory test results on direct shear test. The direct shear test have been used for over many years to determined undrained shear strength parameters of soils. The shear strength of soils is an important aspect in many foundation engineering problems such as the bearing capacity of shallow foundations and piles, the stability of the slopes of dams and embankments, and lateral earth pressure on retaining walls. In this paper, the shear strength characteristics of cohesive soils and the factors that control them will be discussed.

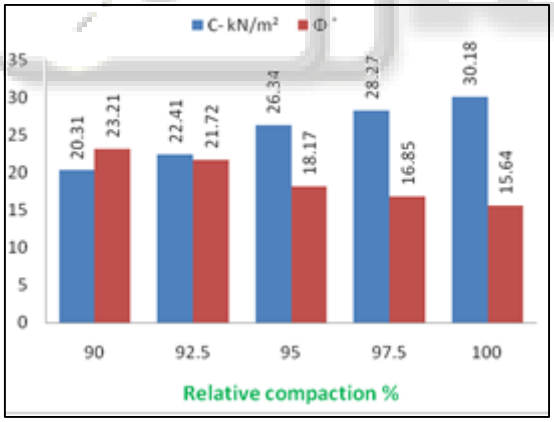

Fig. 6: Chart of C-Φ Parameters

V. 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. Based on this current study using the different relative compaction as observed in remolded samples in the study area, the following conclusions have been drawn.

1) From the test results of cohesion increases approximately 2.0 kN/m2 for each increment of 2.5% of relative compaction. The cohesion of soil increases with related to 90% compaction is 9.4% for 92.5%, 22.89% for 95%, 28.15% for 97.5% and 32.70% for 100%.
2) The angle of internal friction decrease 1.5 ° for each increment of 2.5% of relative compaction. The internal friction decrease with respect to 90% relative compaction 6.41% for 92.5%,21.71% for 95%,27.40% for 97.5% and 32.61% for 100%.
3) In this way the series of experiments take place with the different relative compaction 90%, 92.5%, 95%, 97.5% and 100% on Black cotton soil by which the voids in the soil gets occupied by the compacting increases the shear strength of the soil.

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.

