IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 09, Issue 1 (January. 2019), ||V (I) || PP 27-32

Strengthening of Black Cotton Soils by Using Polypropylene as Fiber Reinforcement

Ravi Kumar GARRE[1], Patlolla Shashidhar Reddy[2]
Assistant Professor, Department of Civil Engineering, KG Reddy College of Engineering and Technology, Hyderabad – 501504, Telangana, India.
Assistant Professor, Department of Civil Engineering, KG Reddy College of Engineering and Technology, Hyderabad – 501504, Telangana, India.
Corresponding Author: Ravi Kumar GARRE

ABSTRACT
Black cotton soils are weak soils, which swells and shrinks excessively with change of water content. The present study is mainly done to stabilize the black cotton soil by using polypropylene as fiber reinforcement. This study is mainly carried out to assess the effects of polypropylene fibers on the shear strength parameters of black cotton soil. For this, I carried out laboratory tests like, direct shear test, unconfined compression test on the collected samples of black cotton soil. The results obtained of these tests were compared for the different reinforcement percentages of 0%, 0.05%, 0.15% and 0.25% of soil samples. But finally, the tests shown positive results and the engineering properties of the soil have been improved.

Keywords: Angle of internal friction, black cotton soil, cohesion, direct shear test, fiber reinforcement, Polypropylene, shrinkage and swelling, Unconfined compression test.

Date of Submission: 18-12-2018 Date of acceptance: 03-01-2019

I. INTRODUCTION

1.1. General

The stability and bearing power of soil is considerably improved by soil stabilization. The soil stabilization can be achieved through addition of suitable admixtures to the soil under controlled compaction and selected proportioning. In the present study I used polypropylene reinforcement to black cotton soil to improve the strength and to stabilize it.

1.2. Black Cotton Soils

Approximately 30% of land area is covered by black cotton soils in India. The black cotton soils are also called as bentonite, expansive soil or cotton soil. They are in color of oil reddish brown to black and the various properties of black cotton soils are shown in **table 1** and the chemical composition of black cotton soil were shown in **table 2**.

Table-1: Properties of black cotton soils

S.No.	Property	Value
1.	Dry density Υ_d	100 to 1800 kg/m^3
2.	Fines (<75μ)	70 to 100%
3.	2μ Fraction	20 to 60%
4.	Atterberg limits Liquid limit L.L. (%) Plastic limit P.L. (%)	 50 to 120 20 to 60
5.	Soil classification	CH or MH
6.	Specific gravity, G	2.60 to 2.75
7.	Maximum dry density	1350 to 1600 kg/m^3
8.	Optimum moisture content	20 to 35%
9.	Free swell Index	40 to 180%
10.	Swelling pressure	50 to 800 kN/m^2
11.	CBR (soaked)	1.2 to 4.0

Black cotton soils contain different properties which effect directly or indirectly the bearing capacity of soil. The chemical and structural composition of black cotton involved in containing different kind of clay minerals and chemical compounds. The minerals such as Montmorillonite, Illite and Kaolinite and the chemicals such as iron oxide, silicon di oxide, calcium carbonate and organic matter like humus are main composition of black cotton soils.

Table-2: Chemical composition of black cotton soils

S.No.	Property	Range
1.	pH value	>7
2.	Organic content	0.4 to 20%
3.	$CaCO_3$	5 to 15%
4.	SiO_2	50 to 55%
5.	Al_2O_3	3 to 5%
6.	Montmorillinite mineral	30 to 50%

Black cotton soils are not suitable for construction works because they usually swell and shrink excessively with change of water content. From this nature, black cotton soils easily undergo volumetric changes due to which differential settlement of structure will take place. In this study the stabilization of black cotton soil has been done by using polypropylene as reinforcement.

1.3. Polypropylene Fiber

Polypropylene is synthetic fiber. For this study it has been chosen due its low cost, hydrophobic and chemically inert nature. The polypropylene is semi-rigid in nature. The polypropylene contains good chemical resistance, good fatigue resistance and good heat resistance. Physically the polypropylene, in appearance tough, transparent and having integral hinge property. The various properties of polypropylene are shown in **table 3.**

Table-3: Properties of Polypropylene fiber material

S.No.	Property	Value
1.	Fiber type	Single fiber
2.	Tensile strength	0.95 to 1.30 N/mm^2
3.	Thermal coefficient of expansion	100 to $150X10^{-6}$
4.	Melting point	160^0C
5.	Density	$0.905g/cm^3$
6.	Average diameter	0.034 mm
7.	Average length	12 mm
8.	Modulus of elasticity	3500 MPa
9.	Fusion point	165^0C
10.	Burning point	590^0C
11.	Acid and alkali resistance	Very good
12.	Dispersive ability	Excellent

The most commonly used plastic in the world is Polypropylene after poly ethylene.The molecular structure of Polypropylene provides additional flexural strength against failure called fatigue resistance.

II. STUDY AREA

For the assessment of effects of polypropylene fiber on black cotton soil's shear strength parameters, the sample of black cotton soil is collected at Bengal gram field, Kandulur village, which located near 8 km from QISIT, Ongole. The field located at 15.2197^0N latitude and 79.925^0E longitude.

III. EXPERIMENTAL METHODOLOGY

3.1. Collection of Samples

To assess the engineering properties of the black cotton soil, a sample has been collected on 8th December 2017, from the study area. The required amount of homogeneous soil is sampled at a depth of 3m below the ground level from a trail pit.Because the soil at the surface contains organic matter and other unwanted matter. To collect the homogeneous soil sample requisite precautions has been considered. And then, the collected sample of soil brought to the soil testing lab, QISIT, Onogole.

3.2. Preparation of Samples

First of all, the collected black cotton soil sample is air dried and passed through 4.75mm sieve. After that, the sample was compacted at its respective maximum dry density and optimum moisture content.

To conduct various tests on the soil, two samples were prepared, one is soil sample without fiber reinforcement. It was prepared by mixing the air-dried soil with an amount of water content at respective optimum moisture content of the soil.

And another is, soil sample with fiber reinforcement. It was prepared by mixing the fiber into the air-dried soil with various proportions 0.05, 0.15 and 0.25, by hand, until to get the homogeneous mixture, and then required amount of water was added.

Finally, we found four samples, to conduct tests in laboratory with fiber reinforcements of 0, 0.05, 0.15 and 0.25.

The fiber content added in the soil, has been represented as the following equation:

$$\rho_f = \frac{Wf}{W}$$

Where, ρ_f = ratio of fiber reinforcement

W_f = Weight of the fiber content

W = weight of air-dried soil

3.3. Tests were Conducted

The following tests were conducted on the soil sample to determine various engineering properties as well as to carry out the project.

1. Free swell index
2. Specific gravity
3. Index properties

i. Liquid limit
ii. Plastic limit
iii. Plasticity index

4. Standard proctor compaction test
5. California Bearing Ration test
6. Direct shear test
7. Unconfined compression test

IV. RESULTS AND DISCUSSION

4.1. Results

The various engineering properties of black-cotton soil like free swell index, specific gravity, liquid limit, plastic limit, optimum moisture content and CBR values, etc., were found out by conducting their respective laboratory tests. The values of those engineering properties were tabulated in **table 4**.

Table -4: Measured engineering properties of the black cotton soil

S. No.	Name of the Parameter	Average Values
1	Free Swell Index	82.14%
2	Specific Gravity	2.60
3	Liquid Limit	43.491%
4	Plastic Limit	19.56%
5	Uniformity Coefficient	1.362
6	Optimum Moisture Content	17.02%
7	Maximum Dry Density	1.96 g/cc
8	CBR Value @2.5mm Penetration	1.64
9	CBR Value @5.0mm Penetration	1.42

And also, to measure the shear strength parameters, direct shear test and unconfined compression tests were conducted on the prepared samples with various proportions of fiber reinforcements. The results of these tests, i.e. cohesion and angle of internal friction from the graph of direct shear test shown in the table-5 and the unconfined compression strengths from the graphs of unconfined compression test tabulated in table-6.

Table-5: Values from Direct Shear Test

S. No.	Proportion of Fiber Reinforcement	Shear Strength Parameter	Values Obtained from graph
1	Un-reinforcement	Cohesion	0.3513 kg/cm^2
		Angle of Internal Friction	27.820
2	0.05%	Cohesion	0.4732 kg/cm^2
		Angle of Internal Friction	29.020
3	0.15%	Cohesion	0.504 kg/cm^2
		Angle of Internal Friction	29.95
4	0.25%	Cohesion	0.5375 kg/cm^2
		Angle of Internal Friction	320

Table-6: Values from Unconfined compressive strength test

S. No.	Proportion of Fiber Reinforcement	Unconfined Compression Strength
1	Un-reinforcement	0.0692 Mpa
2	0.05%	0.0938 MPa
3	0.15%	0.0965 Mpa
4	0.25%	0.1037

4.2. Discussions

From the results of these tests, we found that, by increasing the proportion of polypropylene, the shear stength parameters havebee increased respectively. The gradual increase in shear strength parameters, i.e. cohesion and angle of internal friction with fiber content are shown in fig-1 and fig-2 respectively. And the increase in unconfined compression strength with fiber content showing in fig-3. From figure-1, the graph shows that the net increment in cohesion is 53.0% as cohesion values increases from 0.3153 kg/cm^2 to 0.5375 kg/cm^2. From figure-2, the graph shows that the net increment in angle of internal friction is 15.02% as the values increases from 27.820 to 320. Therefore, the increment in shear strength of the black cotton soil due to the polypropylene as fiber reinforcement is substantial.

Figure-1: Cohesion and Fiber reinforcement

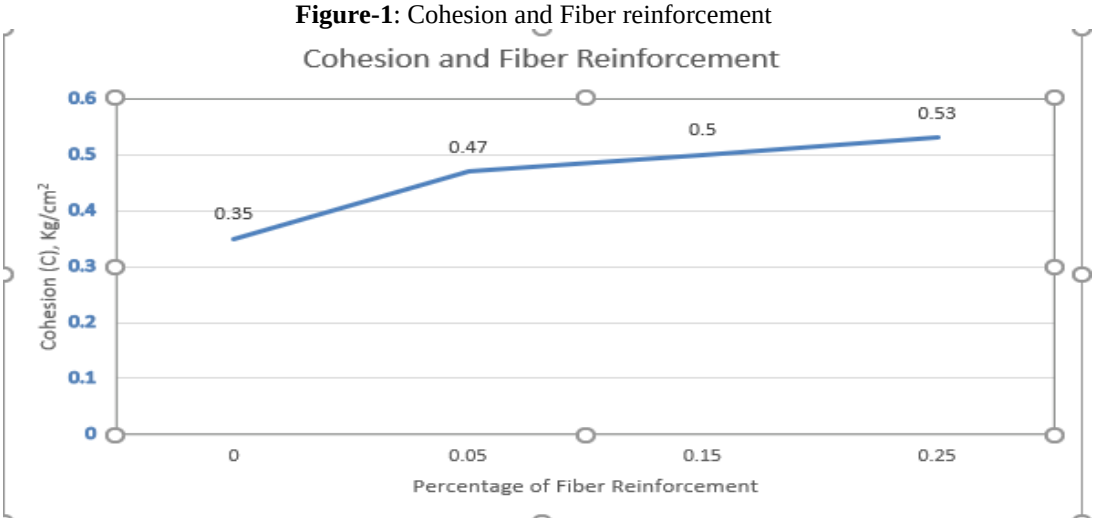


Figure-2: Angle of Internal Friction and Fiber Content

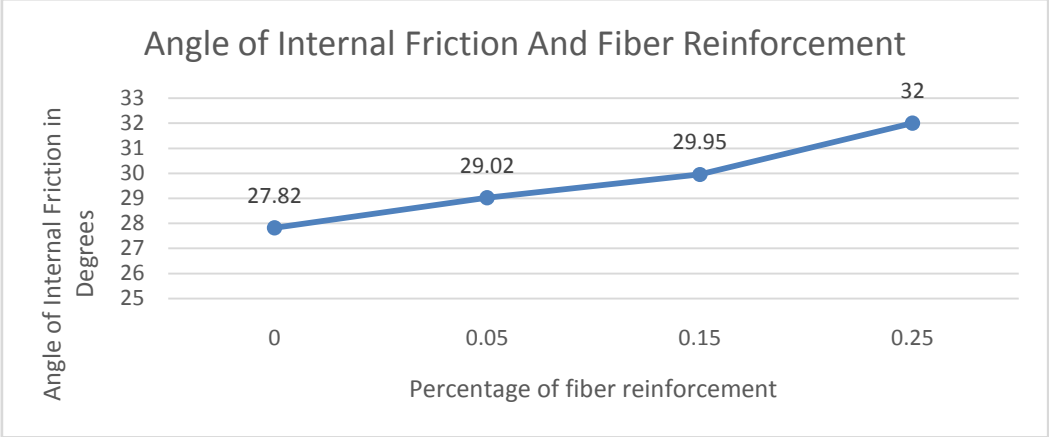
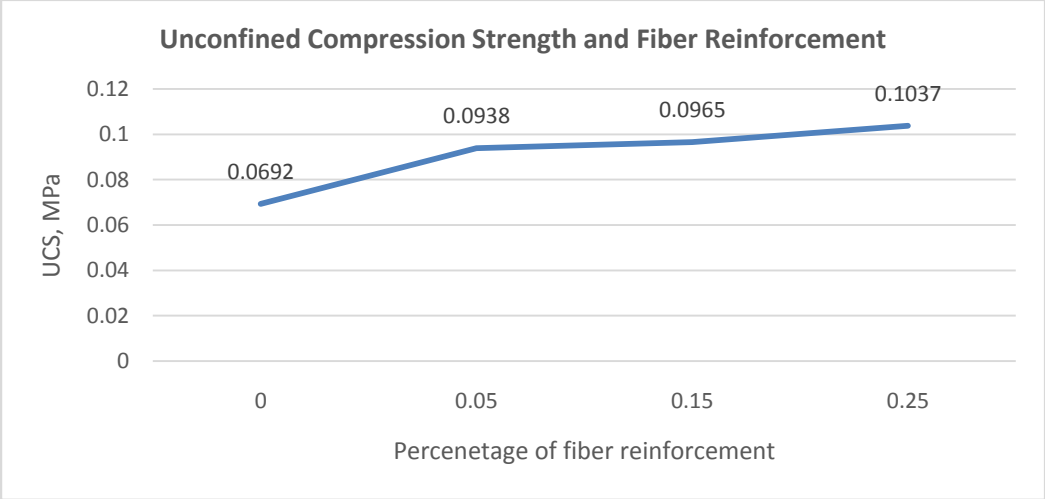


Figure-3: Unconfined Compression Strength and Fiber Content



V. CONCLUSIONS

By observing the results of various tests on the black cotton soil, with and without fiber reinforcement, the following conclusions were made:

1. The free swell index value of soil sample was obtained as 82.14% which is a loose soil and the specific gravity of soil sample was2.60.
2. Index properties of soil sample are the liquid limit value was 43.91, plastic limitas 19.56 whereas the plasticity index of soil sample is 24.35 which was a CL: clay, low plasticity.
3. From the particle size distribution, the uniformity coefficient was1.362.
4. From the standard proctor compaction test, the Optimum Moisture Content(OMC) was 17.02% and Maximum Dry Density (MDD) was 1.96g/cc. From the load- penetration curve at this OMC and MDD, CBR valueincreases.
5. The direct shear tests were conducted on the samples, to determine the shear strength parameters i.e. cohesion and angle of internal friction. From figure- 1, it can be observed that the increase in the value of cohesion has been increased with increase of fiber reinforcement proportion. And from figure- 2, it can be observed that the value of angle of internal friction also has been increased with the increase of fiber reinforcement proportion. From this, we can conclude that to stabilize the black cotton soils, polypropylene fiber is recommended as a good admixture.
6. The unconfined compression tests also were conducted on the prepared soil samples and the unconfined compressive strengths were determined. From figure- 3, it can be observed that the values of unconfined compressive strength have been increased with the increase of fiber reinforcement proportion. From this we can conclude that, to stabilize the black cotton soils, polypropylene fiber is recommended as good admixture.
7. The polypropylene increased the values of engineering properties of soil. The final conclusion is, the fiber reinforcement is the good ground improvement technique.

ACKNOWLEDGEMENTS

The authors thankful to their management for providing them, the necessary infrastructure and labs to carry out this project. They thankful to B. Seshaiah, Professor for his constant encouragement. Ravi Kumar GARRE is mainly thankful to his colleague and co-author K. Gayathri, Assistant Professor, for sharing her knowledge and encouragement and cooperation in doing the project. K. Gayathri saying special thanks to Ch. Sridhar, lab technician for soil testing lab for his valuable advice and helping.

REFERENCES

[1] S. A. Naeini and S.M. Sadjadi, (2008), "Effect of Waste Polymer Materials on Shear Strength of Unsaturated Clays", EJGE Journal, Vol 13, Bid, (1-12).
[2] Yetimoglu. T, Inanir. M, Inanir O. E., 2005, A study of bearing capacity of randomly distributed fiber-reinforced sand fills overlying soft clay. Geotextiles and Geomembranes 23 (2), 174-183.
[3] Chaosheg Tag, Bin Shi, Wei Gao, Fengju Chen, Yi Cai, 2006, Strength and Mechanical Behavior of short propylene fiber reinforced and cement stabilized clayey soil. Geotextiles and Geomembranes 25 (2007) 194-202.
[4] Understanding the Basics of Soil Stabilization: An Over View of Materials and Techniques (online). Available at: http://www.cat.com
[5] Punmia B.C. 2007, "Soil Mechanics and Foundations", Lakshmi Publications.
[6] Yadav Parit, Meena Kuldeep Kumar, (2011)" A comparative study in soil plasticity of Hall area and lecture complex area of NIT Rourkela" B.tech thesis,NIT,Rourkela.
[7] IS: 2720(Part 2), 1973 Methods of Test for Soils, Determination of watercontent.
[8] IS 2720(VII):1980 Methods of Test for Soils, Determination of water content dry density relation using lightcompaction.
[9] IS 2720(XIII):1986 Methods of Test for Soils, direct sheartest
[10] IS 2720(X):1991 Methods of Test for Soils, determination of unconfined compression test.
[11] IS 2720(IV):1985 Methods of Test for Soils, determination of grain sizeanalysis.

Ravi Kumar GARRE. "Strengthening of Black Cotton Soils by Using Polypropylene as Fiber Reinforcement." IOSR Journal of Engineering (IOSRJEN), vol. 09, no. 01, 2019, pp. 27-32.