Experimental Study On Mechanical Properties Of Black Cotton Soil By Using Banana Fibre

Kanchunadham v s somasekhar[1],Chinta sivanarayana[2]

Abstract

Black cotton soil is posing dangerous technical challenges in some areas. Because of their low strength and deformation properties, black cotton soils make it difficult to create buildings. This research included the issues with black cotton soil, their solutions, the safety measures implemented, as well as the construction recommendations. This study aims to investigate the differences in shear strength parameters and CBR values of black cotton soil after reinforced with 0.4 percent, 0.8 percent, and 1.2 percentages of banana fibers, with a 15mm in length. Another effort to study the change in cohesiveness and angle of internal friction values when reinforced at different points in a compaction mould has been made with natural fibers. Experiments are conducted in a controlled environment in a laboratory as part of the systematic process.

KeyWords: Experimental, Mechanical, Properties, Soil.

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1.Introduction

General

Black cotton soils cover a significant amount of Central India and small regions of South India. These soils have exceptionally low CBR values and shear strengths together with strong swelling and need to be improved. In the field of soil engineering, employing reinforced earth is a well-known technique. The idea of stabilizing soil using natural fibers like sisal, banana, and banana fibers is a relatively new technique for enhancing the qualities of soil.

shrinkag  e

Figure 1.1 Major soils types in India

Black cotton soil, which makes up over 23% of the land in India, is a challenging soil that may be found on aggregate up to a depth of 3.7 metres.Due to the rising expense of cement and issues with its production's effect on the environment, cement stabilization is currently not preferred. For soil that contains Sulphates, lime is likewise inappropriate. With these factors in mind, the need for other sustainable resources is the most potential one. The availability of sulphates can exacerbate the swelling behaviour of soil owing to the development of swelling minerals as ettringite and Thomasite. Since cotton is a significant crop that is cultivated in this type of soil, black soil is sometimes referred to as black cotton soil.

Corresponding author: Kanchunadham v s somasekhara
Address: [1]M tech scholar Department of civil Engineering, Bvc engineering college, odalarevu-533210, Andhra Pradesh, India ,[2]Associate professor Department of civil Engineering, Bvc engineering college, odalarevu-533210, Andhra Pradesh, India

Although the phosphorus concentration of this soil is low, it is rich in calcium carbonate, potash, lime, and magnesium carbonate. Areas like Gujarat, Madhya Pradesh, and Maharashtra are where it is most prevalent

1.2 Physical And Chemical Properties Of Banana Fibre

Banana fibre is a natural fibre with high strength, which can be blended easily with soil .Many unsuitable soils for construction purposes can be made suitable by using unconventional soil stabilizers.

S.No	Physical properties	Banana fiber*	White jute	Tossa Jute
1	Single fibre tenacity(gf/tex)	46-64	35-45	35-50
2	Single fibre extension at break (%)	2.9-4.3	1.0-2.5	1.0-1.0-2.5
3	Fibre bundle tenacity(gf/tex)	24-30	13-29	15-31
4	True density(g/cm3)	1.31-1.33	1.44	1.45
5	Apparent density(g/cm3)	.62-.86	1.23	1.23
6	Flexural rigidity	33-40	4-6	4-6
7	Length of raw fibre(cm)	34-85	-	-
8	Moisture regain at 65%r.h	14.0-15.2	12.0	12.0
9	Fiber porosity (%)	35-53	14	14

* The banana species used was Musa sapientum from reference (Gupta et al., 1972).

Table 1.1Physical properties of Banana fibre

Banana is one of the earliest and important fruit crops cultivated by man in tropical parts of the world. Banana is distributed in more than120 countries, over an area of 48lakh hectares, with an annual production of 99.99 million tons in the year 2011 (Indian Horticulture Database, 2011). Banana farming generated huge quantities of biomass all of which goes as waste due to non-availability of suitable technology for its commercial utilization. Normally this biomass is used for animal feed and fuel. It has got shiny appearance depending upon the extraction & spinning process. It is light weight. It absorbs as well as releases moisture very fast. It is bio- degradable and has no negative effect on environment and thus can be categorized as eco-friendly fibre.

PROPERTY OF FIBRE	VALUE
Color	Whitish brown
Average of diameter (mm)	0.1
Aspect ratio (L/D)	150
Cut length (mm)	15

Table 1.2 Properties of fibre

Properties of Banana fibre

Tenacity	29.98%
Fineness	17.15
Moisture Regain	13.00%
Elongation	6.54
Alco-ben Extractives	1.70%
Total Cellulose	81.80%
Alpha Cellulose	61.50%
Residual Gum	41.90%
Lignin	15.00%

Table 1.3 Chemical properties of Bananafibre.

1.3 Applications Of Banana Fibre

The natural fibres are increasing day by day in civil engineering construction works where very high strength of bonding material is not in demand. Natural fibres are cheap, locally available, biodegradable and eco-friendly. Natural fibres used in specified manner and in optimum quantity can cause significant improvement in tensile strength, shear strength, bearing capacity and other engineering properties of the soil.Naturalfibre composites are nowadays being used in various engineering applications to increase the strength and to optimize the weight and the cost of the product. Various natural fibres such as Banana, sisal, jute, Banana and Banana are used as reinforcement materials.

1.4 Objective

The objective of this paper is to investigate the variations in shear strength parameters and values by reinforcing the 0.4%, 0.8% and 1.2% percentage of naturally occurring fibrei. e Bananafibre and checking the variation in CBR values when soil is reinforced with natural fibre grids.

2.Review Of Literature

2.1 General

Fibre reinforcement in soils can be observed in nature. In our day-to-day life, you may notice that the roots of vegetation (natural fibres) stabilize the near-surface soil that has low shear strength, mainly because of low effective stress, on both level and sloping grounds. The presence of plant roots is a natural means of incorporating randomly distributed fibre inclusions within the soil mass.

2.2 Origin Of Black Cotton Soil

2.2.1 Distribution

Black cotton soils (vertisols) have been reported all over the world and have been found to occupy about 2% (257 million hectares) of the total ice-free land area of the earth with 72million hectares occurring in India, 71million hectares in Australia (Swindale, 1988) and 43million hectares is in Africa(Virmani, 1988). Countries reported to have black cotton
soils are Australia (Aitchison, et. al., 1962; Ingles and Metcalf, 1972), Algeria (Afes and Didier, 2000), Botswana,Ethiopia (Mgangira and Paige-Green, 2008), Bulgaria, Hungry, Italy (Dudal and Eswaran, 1985), Togo (Oscar et al.,1977), Nigeria (Ola, 1976, 1983; Osinubi, 2006), South Africa (Van Der Merwe, 1964), Morocco, Chad, Cameroon,Kenya, Zambia, (USAID/BRRI, 1971), Tanzania (Bucher and Sailie, 1984), Sudan (Charlie et al., 1984), India (Michael, 2006; Rao et al., 2001), Ghana (Building and Road Research Institute, 1985;USAID/BRRI, 1971) etc.Figure 1 shows the major distribution of black cotton soils in the world.

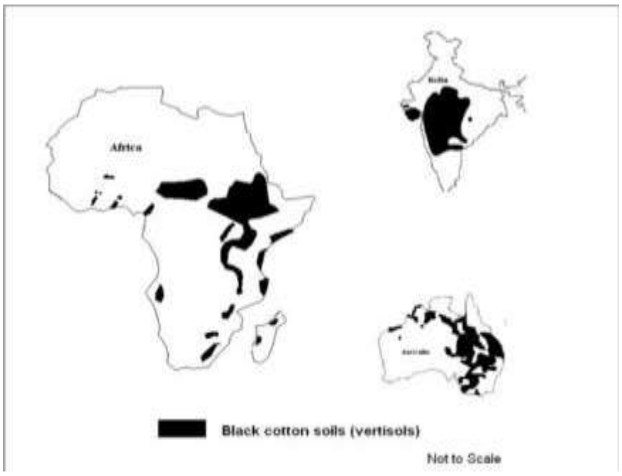


Figure 2.Distribution of black cotton soils(vertisoles) with special reference to areas of major concentrations

2.2.2 Genesis

The black soils are formed by the volcanic eruptions when these cool down and they harden the soil but when they are wet they shrink and when they are dry then they sustain to high cracks which are very wider and broader.

2.2.3 Profile characteristics of black cotton soils

The black cotton soils (vertisolis) have been found to develop on varied topography from the summit to the vailley bottom of the terrain (Cobbina, 1988; Ahmad, 1983; Clemente et al, 1996) and in different climatic zones.
General profile characteristics of black cotton soils vary with parent rock, topography, climate, time etc. Vertisols lack the horizon development diagnostic of other horizons. They have vertic horizon" which is a clayey subsurface horizon Gidigasu and Gawu 381 with slickensides or edge shape or parallelepiped structure aggregates and are characterised by argillipedoturbation(disruption and mixing) caused by swell- shrink of the soil mass. These characteristics are diagnostic features of the black cotton soils.

2.2.4 Brief key points about literature survey

In the last century systematic studies were started to use fibres as soil reinforcement and many researchers have reported about the behaviour of soil reinforced with randomly distributed natural fibres (Gray and Al Refeai, 1986; Mahar and Gray, 1990; Ranjanet.al, 1996; Charan, 1995; Michalowski and Cermak, 2003; Gosaviet al., 2004; Rao et al., 2006; Chanda et al., 2008; Singh, 2011; Fataniet al., 1999; Lawton et. al, 1993; etc.).
Gray and Ohashi (1983) conducted a series of direct shear tests on dry sand reinforced with different synthetic, natural and metallic fibre to evaluate the effects of fibre orientation, fibre content, fibre area ratios, and fibre stiffness. Based on the test results they concluded that an increase in shear strength is directly proportional to the fibre area ratios. Aziz and Ramaswamy (1984 and 1989) used Jute and Banana grid matting for road subgrade strengthening.
Mamta Mishra*, U. K. Maheshwari and N. K. Saxena Department Civil Engineering, Kamla Nehru Institute of Technology, Sultanpur, (U. P.), India. ,October 2016 et al conducted tests and gave the following conclusions.
1.The reinforcement of soil mixed with fly ash further increases the strength of soil used for construction activity.
2. Fibre reinforced soil can be considered to be good ground improvement technique specially in engineering projects on weak soils where it can act as a substitute to deep/raft foundations, reducing

the cost as well as energy.

3. Both the length and content of Banana have important role in developing the strength properties of stabilized soil. But the strength properties are mostly affected by Banana content than by size of Banana fibre.

3.Laboratory Experiments

3.1 General

Keywords

Black soil, reinforcement, Banana fibre, Direct Shear Test, California Bearing Ratio, Standard Proctor Test.

3.2 Materials And Treatment

3.2.1 Black Cotton Soil

Black soils are formed by the weathering of lava and cooling of lava after a volcanic eruption. Mostly a very big part of India known by its famous mane as Deccan Plateau has majority of black soil in India. The black soil required for this experiment was collected from gannavaram, Krishna district excavated from depth of 8 meters.

Figure 3.1 Black soil

3.2.2 Reinforcement

The reinforcing material used in study is Banana Fibre of diameter 160 micrometer with 15mm length.

3.3 Banana Fibre

Banana crops are the one of the most popular fruit crops in the world. Banana crops are the perennial crops. Banana crop waste can be used to create the bio energy. The ratio to Banana waste and product is 2:1.approximately 30 tonnes of waste generated per acre in one crop season from a Banana stem alone in India. Banana Fibres are environmentally friendly and present important attributes, such as low density, light weight, low cost, high tensile strength, as well as being water non absorbent and fire resistant.

Figure 3.2 Banana fibre

3.3 Treatment For Banana Fibre

Banana Fibres were purchased from Guntur, Andhra Pradesh, India. The fibres were then treated with 5% of Na OH for one hour. The fibres are then washed thoroughly with distilled water. Fibres are then dried in oven for 2 hours at 100°C to remove the moisture present in it.

Figure3.5 Fibre seasoning

3.4 Methodology

3.4.1 Phase-1- Understanding Of Soil

In this phase experiments were done for knowing the basic properties of virgin black soil as per IS code standards.

3.4.2 Phase Ii– Laboratory Investigations Of Fibre Reinforced Soil

In this phase, results were obtained to know the variations in properties of virgin black cotton soil when blended with different percentages(0,0.4%,0.8%,1.2%) of fibre.
Phase two is dependent on percentage of fibres added to the soil.
Composition 1 A: Black cotton soil+0.4% of Bananafibre by weight of soil.
Composition 1B: Black cotton soil+0.8% of Banana fibre by weight of soil.
Composition 1C: Black cotton soil+1.2% of Bananafibre by weight of soil.

3.4.3 Phase III – Field Feasibility Studies

Procedure

To clean and dry the density bottle, wash it thoroughly with distilled water and allow it to drain.Find the mass of the empty clean bottle(W1) accurate to 0.001g with it'sstopper.Take about 10 to 20g of oven-dried sample passing through 75 micron sieve in the density bottle. Find the mass of the bottle with the soil and stopper(W2).Put about 10ml of distilled water in the bottle so that soil is fully soaked and entrapped air is removed. Now weigh the bottle along with soil, water and stopper(W3).Now, empty the bottle and wash it. Fill it completely with water alone. Weigh the bottle containing water alone with its stopper(W4).Repeatsteps3to 5 and take two more determinations.

3.5 Atterberg's Limits

Liquid And Plasticlimits Of Soil

Procedure

3.5.1 Liquid Limit Test

Take about 120g of the given soil passing through 425 microns seive and mix thoroughly with distilled water to form a uniform paste.The amount of water to be added shall be such as to require 30 to 35 drops of the cup to cause required closure of the groove.Take a portion of the paste with the spatula and place it in the centre of the cup so that it is almost half filled. Use the grooving tool and cut a clean, straight groove that completely separates the soil pat into two parts.Turn the crank at a rate of about two revolutions per second and count the blows necessary to close the groove in the soil for distance of about 12mm.Take a small quantity of moisture sample in the pre-weighed moisture cups, being sure to take the water content sample from the closed part of the groove. Weigh the sample. Add a small amount of water to the soil in the dish and carefully mix it to a consistency to yield a blow count between 25 to 30+ blows.Repeat the sequence for two additional tests for blow count between 20 &25 and between 15&20 for a total of four tests determinations.Weigh all the dry moisture samples. Compute the water contents.

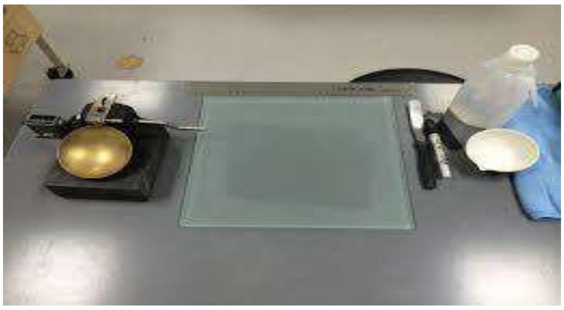


Figure3.6 :Atterbergsapparaturs

3.5.2 Plastic Limit Test

1.Take about 60g of the given soil passing through 425 micron sieve and mix thoroughly with distilled water to form a uniform paste. Break about 20g of soil into 4 peanut-sized samples. Roll the peanut of soil on a glass plate until it just crumbles at 3mm.Place the crumbled soil in the pre-weighted moisture cup, cover with the lid. Repeat the sequence three more times.Weigh the covered canes, remove the lid and place the canes in the oven.Weigh all the dry moisture samples. Compute the water contents.Compute the plastic limit and plasticity index,
Ip=W1-Wp
The toughness index, Itis given by It=Ip/If

Figure 3.7 Plastic limit

3.6 Sieve Analysis: [Is 2720 (Part 4)-1975]

Sieve Analysis helps to determine the proportion of different grain sizes contained within the soil. It can be used to determine the distribution of the coarser, larger-sized and fine particles. Grain size analysis provides the grain size distribution and it is required in classifying the soil. About 500gms of black soil was taken and the soil sample was transferred to a set of sieves. The sample was sieved using a sieve shaker for 10 min. The cumulative percentage of soil retained on each sieve was found out. Grain size distribution curve was plotted.

3.7 Compaction Test [Is 2720 (Part 7) – 1983]

To determine the effect of reinforcing fibres on the moisture density relationships, standard compaction tests were conducted as per Bureau of Indian Standard specifications on virgin black cotton soil and soil – fibre mixtures. An even distribution of fibre and soil was achieved by consistent mixing procedure. About 5kg of soil sample was taken and mixed with water content with varying percentages as 0%, 4%, 6% and 8%.

Figure 3.8 Compaction test

3.8 Direct Shear Test [Is 2720 (Part 13) – 1986]

Direct Shear test helps to determine the shear strength parameters of the soil. The soil specimen was prepared by mixing with different percentages of Banana fibre the black cotton soil and then it was placed in shear box and the soil specimen was sheared at a constant strain rate under different loading conditions.

Figure 3.9 Direct shear test

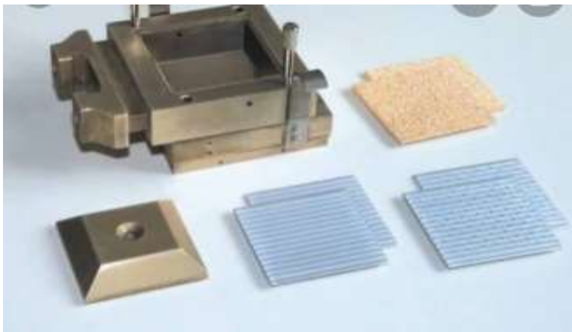


Figure 3.10 shear box

3.9 Unconfined Compression Strength [Is 2720 (Part 10) – 1986]

Unconfined compression strength test helps to determine the compressive strength parameters of the soil. The soil specimen was prepared by mixing with different percentages of Banana fibre the black cotton soil. The samples were prepared at their corresponding maximum dry density and optimum moisture content.

Figure 3.11 Unconfined compressive strength machine

3.10 Sample Preparations With Virgin Black Cotton Soil

3.10.1 Heavy compaction Sample preparation

• Take the soil of 5kg.Then dry it in the sun. Then it will be totally dried and moisture less soil.Next add certain percentages of water to the soil and mix it thoroughly.Then divide the whole soil sample into total 5 parts.Next pour these each sample into the mould and provide 56 gentle blows.

Figure 3.12 Heavy compaction soil specimen

3.11 Direct Shear Test

• Take 250gms of dry soil which is sieved by 425microns.Then add optimum moisture content to the soil.Next mix it properlyPlace the soil sample into the shear box and provide gentle blows for obtaining square shape soil sample.At last take it out from the shear box and place the specimen in direct shear test machine.

Figure 3.13 Prepared soil specimen

Figure 3.14 Direct shear failure specimen

3.12 Unconfined Compression Strength Test Sample Preparation

• Take the soil of 5kg.Then dry it in the sun. Then it will be totally dried and moisture less soil.Next add certain percentages of water to the soil and mix it thoroughly.Then divide the whole soil sample into total 5 parts. Next pour these each sample into the mould and provide 56 gentle blows.Place the sampling soil specimen at the desired water content and density in the large mould.Push the sampling tube into the large mould and remove the sampling tube filled with the soil. For undisturbed samples, push the sampling tube into the clay sample.Saturate the soil sample in the sampling tube by a suitable method.Coat the split mould lightly with a thin layer of grease. Weigh the mould.Extrude the sample out of the sampling tube into the split mould, using the sample extractor and the knife.Trim the two ends of the specimen in the split mould. Weigh the mould with the specimen.Remove the specimen from the split mould by splitting the mould into two parts. Measure the length and diameter of the specimen with vernier calipers.Place the specimen on the bottom plate of the compression machine. Adjust the upper plate to make contact with the specimen.Adjust the dial gauge and the proving ring gauge to zero.Apply the compression load to cause an axial strain at the rate of ½ to 2% per minute.Record the dial gauge reading, and the proving ring reading every thirty seconds up to a strain of 6%. The reading may be taken after every 60 seconds for a strain between 6%, 12% and every 2minutes or so beyond 12%.Continue the test until failure surfaces have clearly developed or until an axial strain of 20% is reached. Measure the angle between the failure surface and the horizontal, if possible.Take the sample from the failure zone of the specimen for the water contentDetermination.

Figure 3.16 Extracted specimens

Figure 3.17 Failure specimes

Fibre Reinforcement

3.13 Sample Preparations With Various Percentages Of Banana Fibre

3.13.1 Heavy Compaction Sample Preparation

• Take the soil of 5kg.Then dry it in the sun. Then it will be totally dried and moisture less soil.Next add certain percentage of water to the soil.

After that add various percentages(0.4%,0.8%,1.2%) of fibre (Banana) and mix it thoroughly

Figure 3.18 Soil and fibre

Figure 3.19 Prepared Sample

Figure 3.20 Sample of heavy compaction test with 0.8% Banana fibre

4.Discussion Of Test Results

4.1 General

Details of the procedures adopted for laboratory experiments carried out on fibre blended back soil were detailed in earlier chapter. In this chapter, a detailed discussion on the results obtained from different laboratory tests in different phases i.e. California bearing ratio, direct shear test and modified standard proctor's test.

4.2 Phase One Test Results

This phase of results for understanding the basic properties of virgin black cotton soil .The following resultswere obtained from laboratory tests as per IS code procedure

4.2.1 Basic Properties Of Black Cotton Soil Obtained From Laboratory

SL.NO	PARTICULARS	VALUE
1	Specific gravity	2.68
2	Free swell index	60.71%
3	Liquid limit	47%
4	Plastic limit	21.17%
5	Plasticity index	28.3

Table

6	Maximum Dry Density(gm/cc)	1.693
7	Optimum moisture content(%)	13.173
8	Cohesion(kg/cm2)	0.045
9	Angle of Internal frictional(Ø)	28.38

4.1Basic properties of virgin black cotton soil

4.2.2 Liquid Limit

The liquid limit of black cotton soil sample is taken at 25 blows, the corresponding moisture content is liquid limit.

Liquid Limit Tabulation

Number of blows	10	26	38	58
Water content(%)	35.4	47.7	45.6	39.5
Weight of container(g)	35.6	34.8	33.2	30.5
Container +Wet sample(g)	57.5	57.6	53.7	56.1
Container +Dry sample(g)	49.7	50.2	47.3	48.8
Wet sample(g)	21.9	22.8	20.5	25.6
Dry sample(g)	14.1	15.4	14.1	18.3

The liquid limit of black cotton soil sample is taken at 25 blows, the corresponding moisture content is liquid limit.

Table 4.2 Moisture content and corresponding number of blows

Moisture content(%)	Number of blows
39.5	58
45.6	38
47.7	26
55.44	10

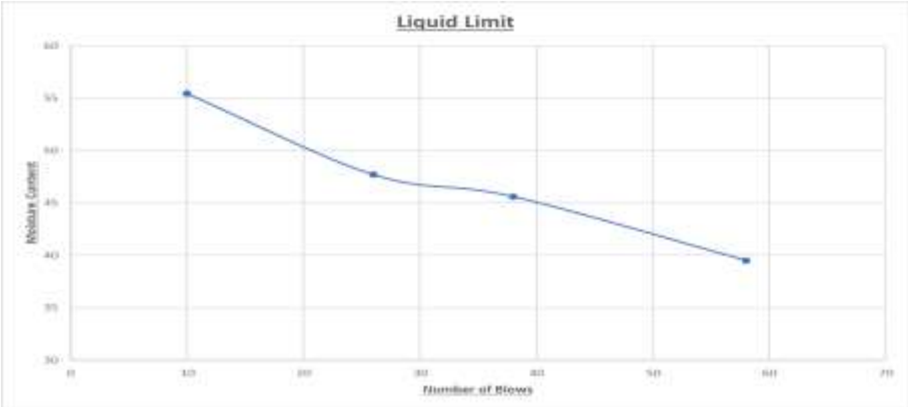


Figure 4.1 Variation in moisture content with number of blows

From flow curve (moisture content vs number of blows)the liquid limit is 47%

Table 4.3 Plastic Limit

Weight of container(g)	29.7
Weight ofcontaine+Wet soil(g)	52.6
Weight of container+Dry soil(g)	48.5
Weight of wet soil(g)	18.8
Weight of dry soil(g)	22.9

From the above table 4.3 the Plastic limit of black cotton soil is 21.17%
Plasticity index = Liquid limit –Plastic limit
= 50-21.17
=28.3

Table 4.4 Identification of soil

Category	Soil	Percentage
1	Sand or silt traces of clay little clay	1-5 5-10
2	Clay loam	10-20
3	Silty clay	20-35

From the table 4.4 the black cotton soil is silty clay

4.2.3 Modified Proctor test

Table 4.5 Calculation of moisture content and dry density of virgin black cotton soil

Percentage of water content add to the soil	4%	6%	8%
Weight of empty cylinder(g)	5.920	5.920	5.920
Weight of cylinder +Compaction soil(g)	9.866	10.235	10.198
Weight of empty container(g)	36.9	35.6	57.4
Weight of container +Wet soil(g)	60.1	54.5	103.7
Weight of container +Dry soil(g)	58.0	52.3	96.8

Table 4.5.1 Variation in Moisture content and dry density

Moisture and dry density of virgin black cotton soil			
Water content(%)	9.925	13.173	17.812
Dry density(gm/cc)	1.595	1.693	1.617

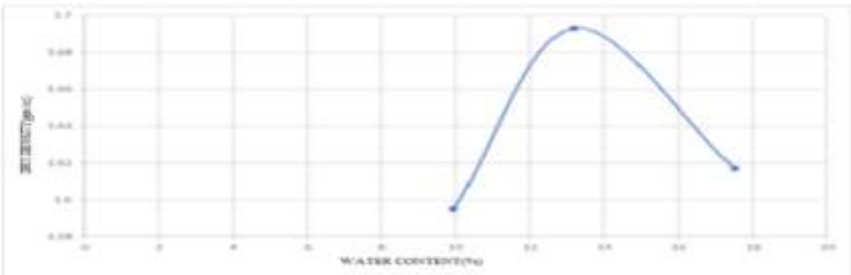


Figure 4.2Variation of Optimum moisturecontent with Dry density

From compaction curve the optimum moisture content=13.173%
maximum dry density=1.693gm/cc

4.3 Phase Two Test Results

In this phase, results were obtained to know the variations in properties of virgin black cotton soil when blended with different percentages of fiber.

4.3.1 Results Of Laboratory Studies

In the laboratory studies standard compaction test, direct shear test and unconfined compressive strength test were conducted on black cotton soil (i.e. Black cotton soil collected at a depth of 20 meters, Gannavaram) which is blended with different percentage of fiber (0.4%,0.8% and 1.2%).

4.3.2 Modified Proctor Test Of Fibre Reinforced

Soil

To determine the effect of reinforcing fibres on the moisture density relationships. About 5kg of soil sample was taken and mixed with water content with varying percentage as 4%, 6%, 8% and 10% Black cotton soil exhibit maximum dry density of 1.693gm/cc and optimum moisture content is 13.173% without any fibre blend.

Onblending of 0.4% ,0.8%,1.2% of Banana fibre with black cotton soil the maxium dry densities 1.609gm/cc,1.61gm/cc,1.793gm/cc and optimum moisture contents 17.025%,18.23% and 17.813% respectively.

Among all compaction test results at 1.2% of Banana fibre attained maximum dry density.

4.3.3 Compaction Curves Of Fibre Reinforced Soil

Compaction curves of Banana fibre reinforced soil with 0.4% fibre

Table 4.6 variation in moisture content and dry density 0.4% Banana fibre

Percentage of water content add to the soil	4%	6%	8%	10%
Weight of empty cylinder (g)	5.920	5.920	5.920	5.920
Weight of cylinder +Compaction soil(g)	9.805	9.850	10.160	10.20
Weight of empty container(g)	34.6	35.6	34.6	37
Weight of container +Wet soil(g)	55.7	77.6	73.9	60.7
Weight of container +Dry soil(g)	55.6	71.7	67.3	57

Variation in moisture content and dry density with 0.4%

0.4% of Banana fibre

Water content (%)	11.052	14.751	17.125	17.910
Dry density(gm/cc)	1.155	1.496	1.608	1.574

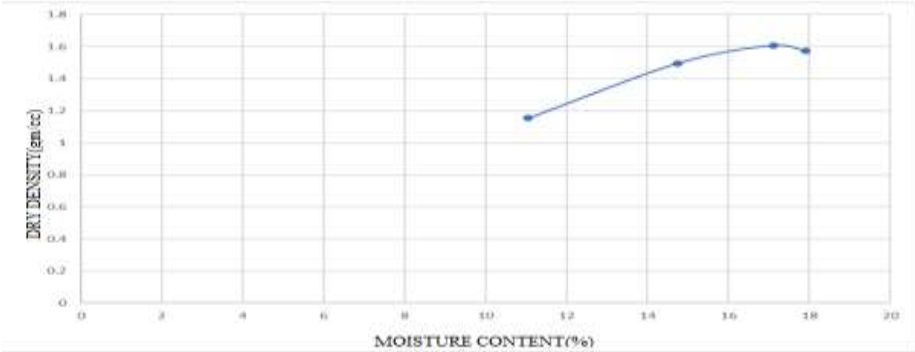


Figure 4.3: Variation of Optimum Moisture Content with Dry density

From compation curve the optimum moisture content=17.125%
the maximum dry density=1.608gm/cc

Table 4.7 Variation in moisture content and dry density 0.8% Banana fibre

Percentage of water content add to the soil	4%	6%	8%	10%
Weight of empty cylinder(g)	5.920	5.920	5.920	5.920
Weight of cylinder + Compaction soil(g)	9.920	9.925	10.10	10.190
Weight of empty container(g)	36.2	54.5	36.3	37.8
Weight of container + Wet soil(g)	83.2	101.9	94.0	80.3
Weight of container + Dry soil(g)	78.4	95.2	85.1	73.7

Variation in moisture content and dry density with 0.8%

0.8% of Banana fibre				
Water content (%)	10.9	14.76	18.23	18.38

Dry density (gm/cc)	1.506	1.590	1.61	1.568

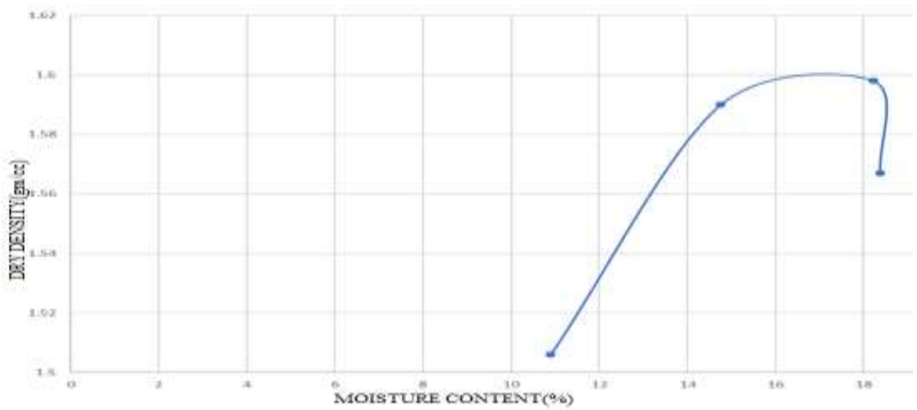


Figure 4.4: Variation of Optimum Moisture Content with Dry density

From compation curve the optimum moisture content=18.23%
maximum dry density=1.61gm/cc

Table 4.8 Variation in moisture content and dry density 1.2% Banana fibre

Percentage of water content add to the soil	4%	6%	8%
Weight of empty cylinder(g)	5.920	5.920	5.920
Weight of cylinder + Compaction soil(g)	9.800	9.955	9.825
Weight of empty container(g)	28.50	36.70	53.70
Weight of container +Wet soil(g)	81.40	90.50	98.10
Weight of container +Dry soil(g)	76.20	85.20	92.30

Variation in moisture content and dry density with 1.2%

1.2% of Banana fibre

Water content (%)	10.901	10.92	15.02

Dry density (gm/cc)	1.554	1.793	1.67

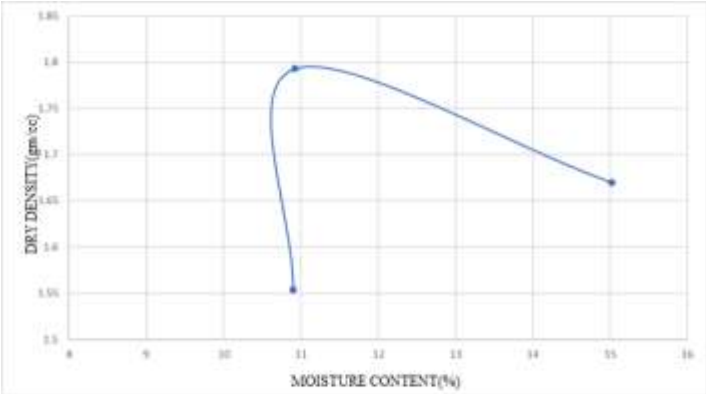


Figure4.5: shows the variation of Optimum Moisture Content with Dry density

From compation curve the optimum moisture content=10.92%
the maximum dry density=1.793gm/cc
From the laboratory tests

Soil with various percentages of fibre	0%	0.4%	0.8%	1.2%
Optimum Moisture Content (%)	13.193%	17.125%	18.23%	10.92%
Max dry density(gm/cc)	1.693 gm/cc	1.609 gm/cc	1.61gm/cc	1.793 gm/cc

The maximum dry density obtained at 1.2% of fibre.
From the laboratory tests

Optimum Moisture Content (%)	13.193%
Max dry density	1.693 gm/cc

Soil with 0% fibre

Optimum Moisture Content (%)	17.125%
Max dry density	1.609 gm/cc

Soil with 0.4% fibre

Optimum Moisture	18.23%

Content (%)	
Max dry density	1.61gm/cc

Soil with 0.8% fibre

Optimum Moisture Content (%)	10.92%
Max dry density	1.793 gm/cc

Soil with 1.2% fibre

The maximum dry density obtained at 1.2% of fibre.
Modified standard proctor's test results to shows the variation in maximum drt density and optimum moisture content between virgin black cotton soil and different percentages of fibre

NAME OF THE MATERIAL	PROPERTIES	VIRGIN SOIL WITH DIFFERENT PERCENTAGES OF WATER CONTENT			
		4%	6%	8%	10%
Virgin black cotton soil	Optimum Moisture Content(%)	9.925	13.173	17.813	17.512
	Dry density(gm/cc)	1.595	1.693	1.617	1.597

NAME OF THE MATERIAL	PROPERTIES	VARIOUS PERCENTAGE OF FIBRE WITH DIFFERENT WATER CONTENT		
		0.4%	0.8%	1.2%
Banana Fibre	Optimum Moisture Content(%)	17.025%	18.23%	17.813
	Dry density(gm/cc)	1.609	1.61	1.793

4.4 Direct Shear Test Of Fibre Reinforced Soil

Direct shear test was conducted on Black soil sample with and without blending fibres.
Virgin black cotton soil exhibit cohesion value of 2.15kg/cm2 and internal friction angle of 35°

On blending of 0.4%,0.8% and 1.2% of Banana fibre with Black cotton soil the cohesion values and Internal friction angle increased to 3.75kg/cm2, 4.1kg/cm2 , 3.5kg/cm2and 38.0,39.50,28.0 respectively

Table 4.9 Shear parameters at different percentages of fibre

NAME OF THE FIBRE	PROPERTIES	PERCENTAGE OF FIBRE			
		0%	0.4%	0.8%	1.2%
Banana Fibre	Cohesion(kg/cm2)	0.045	3.75	4.1	3.5
	Internal Frictional Angle(Ø)	28.38	38	39.5	28

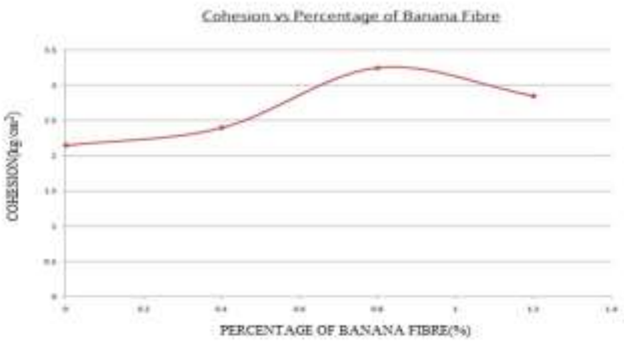


Figure 4.6 Variation in cohesion with different percentages of fibre

The graph shows the variation of cohesion with different percentages of fibre. At 0.8% of Banana fibre soil will achieve maximum cohesion.

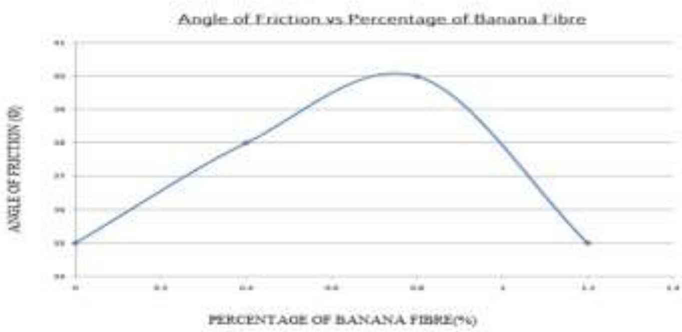


Figure 4.7 Variation in angle of friction with different percentages of fibre

The graphs shows the variation of the internal friction angle with different percentages of fibre. Here we came to know across that at 1.2% of banana fibre the internal friction angle reduced considerably and maximum frictional angle attained at 0.8% of Banana fibre.

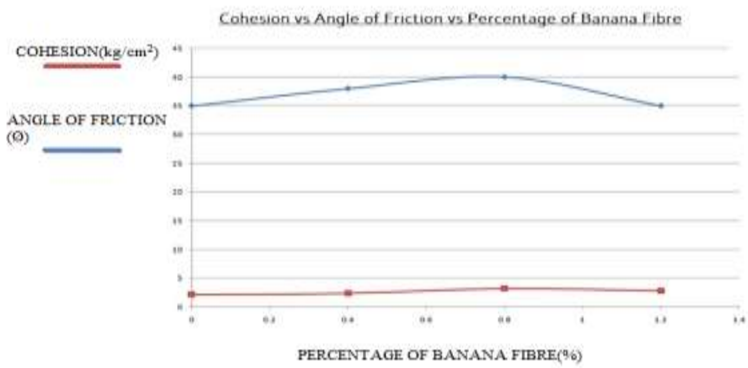


Figure 4.8 Variation in cohiesion and angle of friction with different percentages of fibre

Result

from the above graph the Cohesion and angle of internal friction values are 4.1(kg/cm2) and 39.5 degrees respectively.

Angle of internal friction	Denseness

Less than 28 degrees	Very loose
28-30 degrees	Loose
30-36 degrees	Medium
36-42 degrees	Dense
Greater than 42 degrees	Very dense

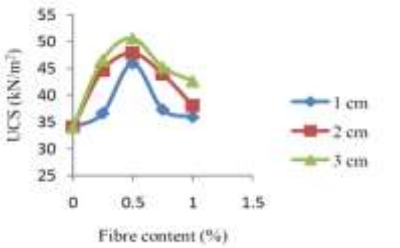
From the classification the above soil is DENSEin nature

4.5 Unconfined Compression Test

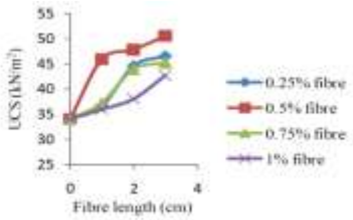
1) Unconfined Compressive Strength of Banana fibre of specific length(1cm,2cm,3cm) reinforced soil: The unconfined compressive strength of soil samples with different percentages(0%,0.4%,0.8%,1.2%) of Banana fibres having specific length were calculated from the loads at failure.

Mix particulars	Fibre length		
	1cm	2cm	3cm
Soil+0% fibre	34.01	34.01	34.01
Soil+0.4% fibre	36.59	44.58	46.51
Soil+0.8% fibre	45.89	47.80	50.56
Soil+1.2% fibre	37.25	43.93	45.22
Soil+1.6% fibre	35.92	38.03	42.64

2) Unconfined Compressive Strength of Banana fibre reinforced soil: The Unconfined Compressive Strength of soil samples with different percentages of Banana fibres of varying length(1cm,2cm,3cm) were calculated from the loads at failure.



Variation of UCS with fibre content



Variation of UCS with fibre length

From The Graph Unconfined Compressive Strength Of Banana Fibre Reinforced Soil

Fibrecontent(%)	0	0.4	0.8	1.2	1.6
UCS(KN/m2	34.01	45.87	54.11	42.93	39.41

The Unconfined Compressive Strength value of banana fibre reinforced soil is highest at 0.5% fibre content.
The maximum compressive strength of banana fibre reinforced soil is 54.11(KN/m2).

5.Conclusions

The following observations from the test results were noted:
The soil that has been strengthened with banana fibre produces outstanding results. Maximum dry density rose by 15% at 1.2 percent banana fibre.
i. Maximum dry density increased by 15% at 1.2

percent banana fibre.

ii. Banana fibre cohesion rose by 90.6 percent at 0.8 percent.

iii. The internal friction angle rose by 13% at 0.8 percent banana fibre.

Based on the aforementioned findings, banana fibre is also recommended for use as soil reinforcement because of the significant improvement in shear parameters, unconfined compressive strength, and dry density.

An improvement of 37% is shown in the unconfined compressive strength of soil reinforced with 0.8 percent banana fibres of randomized length

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