International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 09 | Sep 2021 www.irjet.net p-ISSN: 2395-0072

Stabilization of Bitumen Emuslion Treated Black Cotton Soil Reinforced With Coir Fibre

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Abstract: *The construction of building and other civil engineering structures on theblack cotton soil is highly risky on geotechnical conditions such assettlement of roads and buildings due to low or poor shear strength and highsettlement properties of the clayey soil. There is a need for treatmentof soil so that the properties used are increase. These are not well suited for construction work on account ofits volumetric changes of these soils swell and shrink excessively withchange in water content. In this study we are going to use bitumen emulsion andcoir fibre to modify the properties of black cotton soil as those are easily available in our country. With addition of bitumen emulsion which acts asgood bonding agent with soil particles and coir fibre acts as best crack resisting agent, soil properties are seen to change and hence increase drastically. The variation test investigation performed on Black cotton soil using different percentages of coir fibre at 0.5%, 1%, 1.5% and 2%, bitumen emulsion at 2%, 4%, 6%, 8% . Their low cost, environmentally friendly nature, has owed a lot to its engineering properties. Most importantly, the fibre used is waste in nature and also help in cutting up the costs. With varying different amount of the bitumen emulsion and fibre percentage, the soil properties like unconfined compressive strength and California bearing ratio were found to be increased in much higher proportion than normal black cotton soil.*

Key Words*: *expansive soil, montmorillonite, swell, shrink, unconfined compressive Strength, California bearing ratio, etc

1. INTRODUCTION

Civil engineering problems which often encouraged are multidisciplinary in nature. In the present scenario due to industrialization and urbanization are demanding the different types of infrastructural facilities like highways, railways, bridges, flyovers and constructional apartment etc. These infrastructures must pass through different types of geotechnical deposits. The soil characterization where is from location to location, even death at the same location. Soil is the most plentiful construction material in the world and many regions. It is essentially locally available construction material. Among the available varieties of soil, some soils are composed of both coarse and fine-grained soils, forming well graded matrix and posses good strength for found in structures on them. Fine grained soil posses good strength at low water content, however gradual loose strength increase in water content fine grained soils are characterized by high plasticity fractions of finesand void ratio with low strength and high compressibility. The construction of infrastructure of these deposit posses several problems due to their poor strength and high compressibility characteristics. It is not always possible to find alternative sites to provide foundation to different kinds of structures over them. So, this problem can overcome by providing variable solution like stabilization of soil will improve their strength and reduction in the compressibility of the soils.

1.1 Stabilization

Soil stabilization is the process of changing the soils to improve their physical properties, compressive strength and thus improving the load bearing capacity
of a subgrade to support pavements by blending and mixing with other materials.
A few types of soil stabilization methods shown below.

1. Mechanical stabilization
2. Chemical stabilization
3. Geo-synthetic stabilization

2. MATERIALS AND PROPERTIES

2.1 Black Cotton Soil

The Black Cotton Soil named as expansive soil which is deposited 20% surface area in the India and it made by volcanic rocks. Black cotton soil is one amongst the most problematic soil for civil engineering construction point of view due to the presence of mineral montmorillonite and few in elite. Expansive soil prevails generally in central and southern part of India.
Soil used in this research study is obtained from near ring road Hassan district, Karnataka state, India. The soil is collected from an open excavation at a depth 1m below the natural ground surface. The soil was dried in oven and

sieved through 425 microns IS sieve before using it for investigation.

Fig-1: Black Cotton Soil

Table-1: Basic Properties of Black Cotton Soil

SL.NO	PARTICULARS	BLACK COTTON SOIL
1.	Colour	Black
2.	Specific gravity	2.51
3.	Gravel(%)	16.28
4.	Sand(%)	82.18
5.	Clay(%)	1.54
6.	Liquid Limit(%)	72
7.	Plastic Limit(%)	52.5
8.	Plasticity Index (%)	35.78
9.	IS Classification	CH
10.	Maximum Dry Density (MDD) in (KN/m3)	15.97
11.	Optimum Moisture Content (OMC)in (%)	22

2.2 Bitumen Emulsion

Medium Setting (MS) Emulsion was obtained by plant Hassan branch office Karnataka, India. It is one of the dispersions of small droplets by one liquid in another liquid and most of the emulsion phase is water. Its produced batch orans in line process and bitumen emulsion classified as Rapid Setting Emulsion, Medium Setting Emulsion and Slow Setting Emulsion.

Fig-2: Bitumen Emulsion

2.3 Coir Fibre

Coconut husk is the fibrous material of a matured coconut which has high tension strength. The fibres are usually 0.1–0.6mm in diameter and 50- 350mm in length. It is best suitable for reinforcing the soil during construction of roads and some time. Coir fibres were collected from "KARNATAKA TENGINA NAARU UTPANNA KENDRA", Holenarsipura and used to get coir fibre which is locally available material. These fibres were cut randomly by scissor in pieces of 50 to 110mm to maintain the aspect ratio of 150.

Fig-3: Coir Fibre

Table-2: Basic Properties of Coir Fibre

SL.NO	PROPERTIES	VALUE
1.	Diameter	0.5mm
2.	Length	20 to 30mm
3.	Specific Gravity	1.25

3. METHODOLOGY

In the present work Black Cotton Soil was stabilized by using bitumen emulsion with coir fibre as reinforcement. The geotechnical properties for Black Cotton Soil and also various combination are determined. The Specific Gravity, Atterberg's Limits,Sieve Analysis, Compaction studies and Unconfined Compressive Strength(UCS) and CBR test are conducted to evaluate the efficacy of Bitumen Emulsion(BE) and Coir Fiber(CF) in the stabilization Black Cotton Soil. The UCS test conducted for various curing periods i.e. 0, 7 days. CBR test was conducted under soaked and unsoaked condition. The combinations are shown in table 3and 4.

Table-3: Combination of Materials

SL.NO	BCS+BE	BCS+4%BE+CF
1.	BCS+2%BE	BCS+4%BE+0.5%CF
2.	BCS+4%BE	BCS+4%BE+1%CF
3.	BCS+6%BE	BCS+4%BE+1.5%CF
4.	BCS+8%BE	BCS+4%BE+2%CF

4. TEST CONDUCTED

1. **Specific Gravity**
   As per IS:2720(part-3/sec-1)-1980
2. **Grain Size Analysis**
   As per IS:2720(part-4)-1985
3. **Atterberg's Limits**
   - Liquid Limit

   As per IS:2720(part-5)-1985

- Plastic Limit

As per IS:2720(part-5)-1985

4. **Mini Compaction Test**
5. **Unconfined Compressive Strength Test**

As per IS:2720(part-10)-1973

6. **California Bearing Ratio Test**

As per IS:2720(part-16)- 1979-1980

5. RESULTS AND DISCUSSION

1. Specific Gravity Test

Table-4: Specific gravity of BCS treated with bitumen emulsion and coir fibre.

SL.NO	COMBINATION	SPECIFIC GRAVITY
1.	BCS Soil	2.51
2.	Coir Fibre	1.25
3.	BCS+1%CF	2.44
4.	BCS+4%BE+1%CF	2.38

From table-4 it was found that, the specific gravity of black cotton soil and coir fibres are 2.51 and 1.25 respectively. Addition of optimum 1% coir fibres to black cotton soil, the specific gravity decreases 2.44 compared with black cotton soil alone. The decrease in the specific gravity is due to the replacement of lowerdensity coir fibres with higher density of clayey particles of black cotton soil resulting in the decrease in specific gravity. Further addition of optimumlime to black cotton soil along with optimum percentage of coir fibres, the specific gravity was found to be decrease of specific gravity of black cotton soil.

2. Atterberg's Limit Test

Table-5: Liquid Limit and Plastic Limit of BCS treated with bitumen emulsion.

COMBINATION	LIQUID LIMIT(%)	PLASTIC LIMIT(%)	PLASTICITY INDEX(%)
BCS alone	72	52.5	35.78
BCS+2%BE	70	49.2	33
BCS+4%BE	65	44	29
BCS+6%BE	60	38	26
BCS+8%BE	58	32.5	25

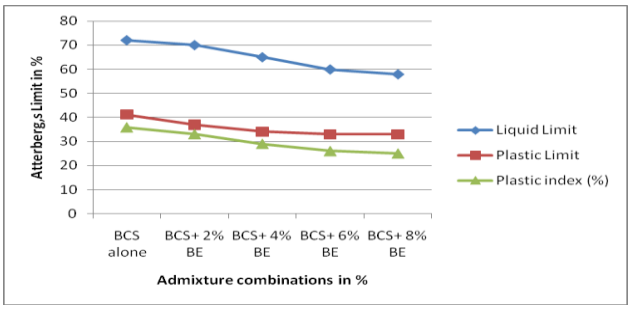
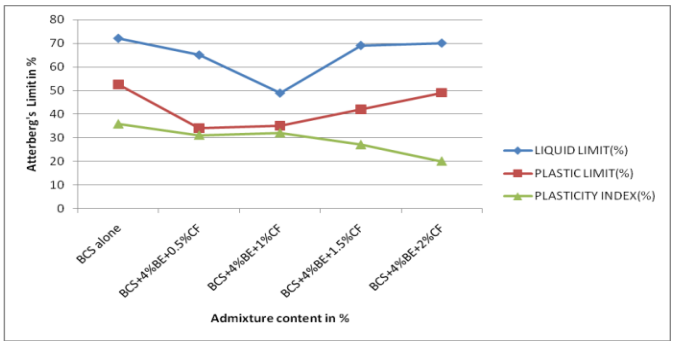


Table-6: Liquid Limit and Plastic Limit of BCS treated with optimum bitumen emulsion and Coir Fibre.

COMBINATION	LIQUID LIMIT(%)	PLASTIC LIMIT(%)	PLASTICIT Y INDEX(%)
BCS alone	72	52.5	35.78
BCS+4%BE+0.5%C F	65	34	31
BCS+4%BE+1%CF	49	35	32
BCS+4%BE+1.5%C F	69	42	27
BCS+4%BE+2%CF	70	49	20

Based on the results it is concluded that bitumen emulsion content of 4% is optimum. In order to improve the geotechnical properties of this mixture to a significant scale . It is treated with various dosage of bitumen emulsion as per experimental program. Consistency limits of soil- bitumen



emulsion treated with coir fibre is determined immediately. Results obtained from these experiments were presented in Table 5and 6.It represents variation in consistency limits of soil- emulsion mixture treated with coir for immediate testing.

3. Compaction test

Table-7: Optimum Moisture content(OMC) and Dry Density(MDD) of BCS treated with various combinations of Bitumen Emulsion.

COMBINATION	OMC(%)	MDD(KN/m3)
BCS alone	22	15.97
BCS+2%BE	20	16.45
BCS+4%BE	19	16.76
BCS+6%BE	17.11	16.13
BCS+8%BE	16.3	14.73

Graph-1: Showing the OMC and MDD relation for various combination of BE.

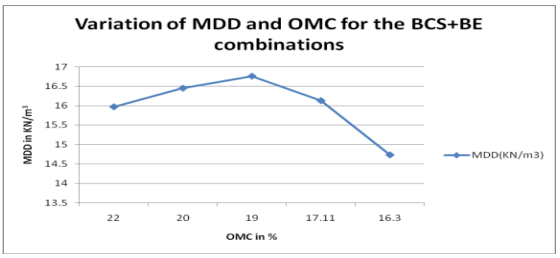
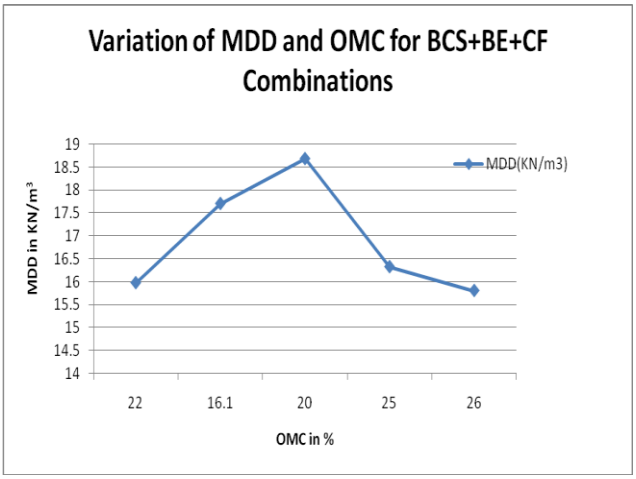


Table-8: Optimum Moisture content(OMC) and Dry Density(MDD) of BCS treated with optimum Bitumen Emulsion and various combinations of Coir Fibre.

COMBINATION	OMC(%)	MDD(KN/m3)
BCS alone	22	15.97
BCS+4%BE+0.5%CF	16.1	17.7
BCS+4%BE+1%CF	20	18.68
BCS+4%BE+1.5%CF	25	16.32
BCS+4%BE+2%CF	26	15.8



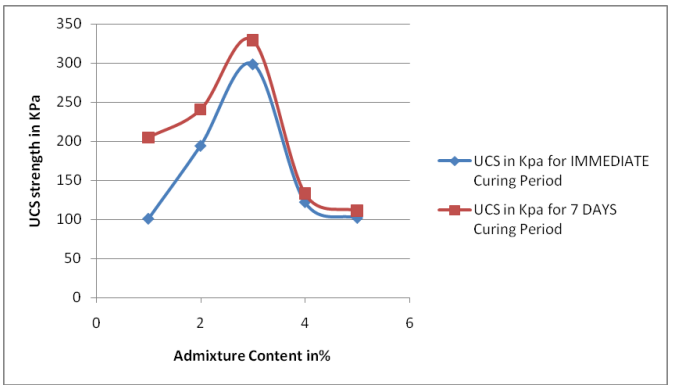
Graph-2: Showing the OMC and MDD relation for optimum BE and combination of CF.

Based on the results of compaction tests conducted for various percentage of bitumen emulsion it is concluded that bitumen emulsion content of 4% is optimum for achieving maximum possible strength in compacted soil- bitumen emulsion composite. In order to improve compaction properties of this composite to a significant scale it is treated with coir fibre. Compaction test were carried out on (soil + 4%BE) mixture treated with coir fibre content varying from 0.5% to 2% at an increment of 0.5%. The results from these experiments are summarized in Table 7 and 8. Graph 1 and 2 shows water content – dry unit weight relationship for Soil- Bitumen Emulsion mixture with Coir Fibre.

4. Unconfined compressive strength (UCS) test

Table-9: UCS value of BCS treated with various combinations of Bitumen Emulsion.

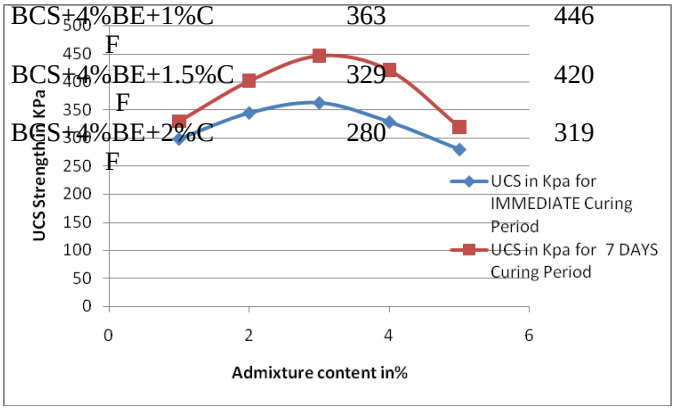
COMBINATION	UCS in Kpa	
	CURING PEROID in Day	
	IMMEDIATE	AFTER 7 DAYS
BCS alone	100.9	204.9
BCS+2%BE	194.3	240.6
BCS+4%BE	298.7	329.29
BCS+6%BE	122.2	133.4
BCS+8%BE	102	111.3



Graph-3: Showing the variations of UCS value for different combinations of BE.

Table-10: UCS value of BCS treated with optimum content of Bitumen Emulsion and various Combination of CF.

COMBINATION	UCS in Kpa	
	CURING PEROID in Day	
	IMMEDIATE	AFTER 7 DAYS
BCS+4%BE+0%CF	298.7	329.29
BCS+4%BE+0.5%CF	345	401
BCS+4%BE+1%CF	363	446
BCS+4%BE+1.5%CF	329	420
BCS+4%BE+2%CF	280	319



Graph-4: Showing the variations of UCS value for optimum content of BE and various combination of CF.

The Unconfined compressive strength of black cotton soil and bitumen emulsion with varied percentage increases the strength for both immediate as well as with curing periods. From the Table8 and Graph 3 , Strength increases up to 4% addition of bitumen emulsion to black cotton soil beyond 4% addition of bitumen emulsion may be due to weak bonding between the soil particles with bitumen emulsion or due to increase in diffuse double layer thickness, thereby leading to a decrease in strength. Also, clay-silt interaction increases which leads to the

reduction in the resistance offered by the densification and hence MDD increases which resulted in increase in strength. Further addition of bitumen emulsion beyond 4%, the strength decreases due to % of silt-silt interaction is more rather than clay-silt interaction. The resistance offered by the BCS +BEagainst compacting energy decreases. This leads to reduction in MDD which causes the decrease in strength. Hence 4% of bitumen emulsion to black cotton soil has been chosen as the optimum percentage. From the Table 9 and Graph 10, shows that addition of 0.5% to 2% of coir fibre to the optimum BCS and BE mixture, the strength increases up to 1% addition of coir for different curing periods. Hence 1% is considered as optimum percentage.

5. California Bearing Ratio (CBR) test

Table-11: CBR value of BCS treated with Optimum content of BE and optimum Content of CF under Unsoaked condition.

COMBINATION	PENETRATION OF PLUNGER in mm	STANDARD LOAD in KG	UNSOAKED(CBR) in %
BCS alone	2.5	1370	2
	5	2055	1.8
BCS+4%BE	2.5	1370	6
	5	2055	5.56
BCS+4%BE+1% CF	2.5	1370	10.62
	5	2055	9.85

Table-12: CBR value of BCS treated with Optimum content of BE and optimum Content of CF under Soaked condition.

COMBINATION	PENETRATION OF PLUNGER in mm	STANDARD LOAD in KG	SOAKED (CBR) in %
BCS alone	2.5	1370	1.13
	5	2055	1
BCS+4%BE	2.5	1370	4
	5	2055	3.7
BCS+4%BE+1% CF	2.5	1370	7.716
	5	2055	7.29

BE mixed with BC soil in optimum % BE i.e., 4% with 1% of CF for both unsoaked and soaked condition, then CBR values in percentage is determined. By comparingthe CBR values of soil alone and soil treated with optimum dosage of bitumen and coir.From the Table 11, CBR value of (soil+4% BE) is increased by 72% than soil alone in unsoakedcondition and increased by 70% than soil alone in soaked condition. From the Table 12 , CBR value of (soil+4% BE +1%CF) is increased 95% in unsoaked condition and by 85% in soaked condition than soil alone in both the conditions. Thus, strength of the sub-grade soil can be increased and also the supporting power of soil gets increased and thickness of the pavement can be reduced.

6. CONCLUSIONS

Based on the results obtained from detailed analysis of the results, the conclusions of the study can be summarized as follows.

- The specific gravity of black cotton soil blended with coir fibres decreases compared to BCS alone. This is due to the replacement of lighter density coir fibres to higher density clayey particles of the soil and reduced from 2.51 to 2.389.
- BCS treated with bitumen emulsion and coir fibre, plasticity index decreases.
- The maximum dry density and optimum moisture content increase up to optimum percentage on addition of coir fibre, beyond 1% addition of coir fibre to BCS the MDD decreases but water demand keeps on increasing, thus the OMC increases. This is due to the blending of coir fibre to the soil. And also, capacity of water absorption is more on coir fibre.
- Further addition of optimum percentage of bitumen emulsion that is 4% to the BCS and coir fibre mixture both MDD and OMC increases up to maximum level later on the MDD decreases beyond the addition of 4% bitumen emulsion. This reduction in MDD may attributed to replacement of bitumen emulsion-soil mixtures which has relatively lower specific gravity than that of the soil.
- Unconfined compressive strength, shear strength increased for 4% bitumen emulsion + 1% coir fibre mixture immediately tested sample and also as the curing period increases the shear strength increases significantly for immediate and 7 days.
- CBR values of BCS alone and soil treated 4% of bitumen emulsion and 1% of coir fibre is increased by 95% in unsoaked condition and by 85% in soaked condition. Thus, strength soil can be increased and thickness of the pavement can be reduced.

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