Improvement of Strength And Stability of Black Cotton Soil Using Unburnt Agricultural Wastes

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Abstract- *Black cotton soilsare highly problematic because of their property of high degree of swelling and shrinkage. These soils when encountered as sub grade of Pavement constructions pose problems in the form of cracking and increased maintenance. Depending upon the use of Black cotton soils as foundation support or construction materials, their properties need careful studies to estimate their potential for damages based on volume change with reference to the imposed structural loads and the tolerance of structures for maximum settlement, differential settlement etc. Considering the requirement of the structural tolerance required, proper remedial measures are to be thought of for controlling the effect of expansive properties of the soil on the structure. Among several techniques adopted to overcome these problems posed by Black cotton soils, stabilization gained prominence during the past few decades due to its abundance and adaptability. In recent years, soil stabilization by using various wastes was a most common practice. These solid wastes are day by day increasing in India, which is not environmental friendly hence they have to be recycled. Soil stabilization is the process by which strength properties of soil can be improved with the use of adding some materials like rice husk ash, phosphor gypsum and waste fibers etc. There is a rapid increase in waste quantity of rice husk ash, these waste materials are generally dumped or thrown, which may deteriorate the ecology and environment. Hence, in this project, an attempt has been made to study the influence of two wastes, Rice Husk Ash (RHA) and Metakaolin (MK) in different percentages, as stabilizing materials and also further enhancing the properties by mixing it with Coir Fibres (CF). Different characteristics of treated Black cotton soil are done by conducting various tests in the laboratory. The results will be analyzed to assess the influence of the materials used.*

Keywords- Black cotton soil, Rice Husk Ash (RHA), Metakaolin (MK), Coir Fibres (CF), Atterberg's limit test, CBR test, Un confined compression test, maximum dry density and optimum moisture contenttest.

I. INTRODUCTION

Soil is a precious resource that humans depend upon for all activities. With each passing day, the pressure on soil due to human activities is increasing. Acute shortage of land has come to the forefront due to the development activities of modern man. Land becomes more scarce with growth of cities and it often becomes essential to construct buildings and other structures on sites where unfavorable conditions are present. Certain soils like Black cotton soils are extremely problematic and cause a wide range of problems to a geotechnical engineer. Black cotton soils are the soils which swell significantly when they come in contact with water and shrink when the water squeezes out. It has long been known that volume change behavior of Black cotton soils causes severe distress to the overlying structures. Due to volume change, the soils exert pressure on overlying structures resulting in cracks in sidewalks, basement floors, driveways, pipelines, and foundations.

Soil stabilization can be explained as the alteration of the soil properties by chemical or physical means in order to enhance the engineering quality of the soil. The main objectives of the soil stabilization are to increase the bearing capacity of the soil, its resistance to weathering process and soil permeability. The long-term performance of any construction project depends on the soundness of the underlying soils. Unstable soils can create significant problems for pavements or structures, Therefore soil stabilization techniques are necessary to ensure the good stability of soil so that it can succesCFully sustain the load of the superstructure especially in case of soil which are highly active, also it saves a lot of time and millions of money when compared to the method of cutting out and replacing the unstable soil. This project report deals with a parametric study on the influence of RHA, Metakaolin (MK) and Coir Fibres in stabilizing the problematic Black cotton soil.

OBJECTIVES OF THESTUDY

The study is focused on

- Improvement of locally available soil using some eco-friendly and cheap waste materials.
- Evaluation of strength characteristics of virgin as well as blended soil using different ratio of RHA, Metakaolin (MK) and Coir Fibres
- Determination of appropriate soil, RHA and Metakaolin (MK) content ratio to achieve the maximum gain in strength from the mixture.

II. LITERATUREREVIEW

2.1 **Studies on lateritic soil**

Recent research works conducted on stabilization of Black cotton soil using different stabilizing agents were referred and their summary was listed below:

The common chemical compositions of laterites according to Gidigasu (1976), Ola (1983) and Osinubi (2003) are silica (SiO2), sesquioxide of iron (Fe2O3) and aluminum (Al2O3), and in some few cases, little quantities of manganese (Mn), titanium (Ti), chromium (Cr) and vanadium (V). Though silica is low in most laterite deposits, higher amounts are found in some few laterite deposits where the parent rock contains a lot of quartz.

George R. Otoko presents the experimental study on Soft Soil Stabilization Using Palm Oil Fibre Ash and the analysis shows that the palm ash is classified as class F according to ASTM C618. It is siliceous and aluminous with virtually little or no cementation value. Therefore for pozzolanic reaction it has to be combined into a little lime. An Optimum of 5% lime was obtained for pozzolanic reaction. This combines with 3% optimum palm ash to give best results of soaked and unsoaked CBR. Thus, the palm ash can successfully be used for soil subgrade stabilization

Dayakar, Sree, Prasad and Madhurimanmadha, (2003) conducted laboratory investigation for stabilization of Black cotton soil using silica fume and tannery sludge with percentage of solid wastes varying from 0, 10, 20,30, 40, 50, 60- 70%. The addition of wastes did not improve the index properties and maximum dry density but there was gain in strength of the Black cotton soil with both tannery sludge and silica fume up to 15%.

Okagbue (2007) evaluated the potential of wood ash to stabilize clayey soil. Results showed that the geotechnical parameters of clay soil are improved substantially by the addition of wood ash. Plasticity was reduced by 35%, CBR, UCS increased by 23–50% and 49–67%, respectively, depending on the compactive energy used. The highest CBR and strength values were achieved at10% wood ash.

Ramírez, Montes, Martínez, Altamirano and Gochi, (2012) noted that Bagasse ash exhibits satiCFactory behavior in blended cementitious materials in concrete and has greater potential for use in other applications. The addition of 10% Bagasse ash increased the compressive strength of cement paste at all ages of hydration. The chemical deterioration of blended cement is also reduced due to the pozzolanic nature of Bagasse ash and the reduced permeability of Bagasse ash-containing mixtures. Replacement of fine aggregate with up to 20% by Bagasse ash resulted in equivalent or higher compressive strength and reduced water permeability and chloride diffusion Chusilp, Likhitsripaiboon, and Jaturapitakkul, (2009).

2.2 STABILIZATION

Soil stabilization is the process of altering some soil properties by different methods, mechanical or chemical in order to produce an improved soil material which has all the desired engineering properties. Soils are generally stabilized to increase their strength and durability or to prevent erosion and dust formation in soils.. The properties of soil vary a great deal at different places or in certain cases even at one place; the success of soil stabilization depends on soil testing. Various methods are employed to stabilize soil and the method should be verified in the lab with the soil material before applying it on the field.

2.3 METHODS OF SOIL STABILIZATION

- Mechanical Stabilization.
- Soil Cement Stabilization.
- Soil Lime Stabilization.
- Soil Bitumen Stabilization.
- Thermal Stabilization.
- Chemical Stabilization.

III. LABORATORY EXPERIMENTATION

The soil was initially air dried prior to the testing. The tests were conducted in the laboratory on the Black cotton clay to find the properties of virgin Black cotton soil.

3.1 LIST OF TESTS CONDUCTED

The following tests were conducted as per IS codes of practice.

- Specific gravity of soil

- Determination of soil index properties (Atterberg Limits)
  - Liquid limit
  - Plastic limit
- Particle size distribution by sieve analysis
- Determination of the maximum dry density (MDD) and the corresponding optimum moisture content (OMC) of the soil by Proctor compaction test.
- Penetration tests-California bearing ratio test
- Unconfined Compression Test-Triaxial

IV. METHODOLOGY

4.1BLACK COTTON SOIL

The soil used was a typical black cotton soil collected from the soil used was a typical black cotton soil collected from Appaniramuni Lanka, Near Dindi village, Sakhinetipalli Mandal, East Godavari district, Andhra Pradesh State, India. The properties of soil are presented in the Table All the tests carried on the soil are as per IS specifications. Table 3.1 shows properties of soil.

TABLE 4.1 Properties of Black cotton Soil

S. NO.	PROPERTY	VALUE
1	Specific gravity	2.66
2	Differential free swell Index (%)	105
3	Atterberg's Limits	
	i) Liquid limit (%)	70.5
	ii) Plastic limit (%)	26.9
	iii) Plasticity index (%)	43.6
5	Grain Size Distribution	
	i) Sand Size Particles (%)	13
	ii) Silt & Clay Size Particles (%)	87
6	IS soil classification	CH
7	Compaction Parameters	
	i) Max. Dry Density (g/cc)	1.41
	ii) Optimum Moisture Content (%)	28.2
8	Penetration Parameters	
	i) CBR - Soaked (%)	1.7
9	Shear Parameters at OMC & MDD	
	i) Cohesion, Cu (kPa)	40
	ii) Angle of Internal Friction, Øu (Degrees)	0

4.2 RICE HUSK ASH

For the present study, the rice husk ash has been brought from the lalitha rice mill, peddapuram, Andhra Pradesh

Table 4.2 Properties of Rice Husk Ash (RHA)

S. No.	Property	Value
1	Specific gravity	1.12
2	Atterberg's Limits	
	i) Plasticity index (%)	NP
3	Grain Size Distribution	
	i) Sand Size Particles (%)	24
	ii) Silt & Clay Size Particles (%)	76

4.3 METAKAOLIN

Metakaolin (MK) is a thermally activated aluminosilicate material, white in colour with a dull luster, obtained by calcining kaolin clay within the temperature range 6500-80000C. In the present investigation, Metakaolin marketed by Jeetmull Jaichandlall Pvt. Ltd. Chennai, Tamilnadu was used. The physical and chemical characteristics furnished by the manufacturer are moisture content of 0.18 %, specific gravity of 2.65, bulk density of 710 kg/m3 and pH of 7.0. Metakaolin consists majorly of SiO_2, Al_2O_3, and Fe_2O_3 contributing 53.7 %, 39.2 %, 3.84 %, of the total. The next most abundant component is titanium oxide, TiO_2 (5.97 %). According to ASTM standard specification (C618 – 2012), the sum of SiO_2, Al_2O_3, Fe_2O_3 be $\geq$ 70 % for any material to be used as a pozzolana.

4.4 COIR FIBERS

Coir fiber is a degradable material, use of natural fibre for improving soil properties in civil engineering is a result of its low price, local availability, biodegradability and environmentally friendly. Reinforcing the soil with fibre Coir Fibre may be a cost effective solution to the ground/soil improvement issues. It is an important commercial product used in mattress. Diameter of the fiber is 0.3 to 0.5 mm. The coir is cut into pieces of length varying from 3cm to 5cm. The fibers are mixed randomly in the soil-coal ash mixture during experiments in various percentages as 0.50, 1.0, 1.5 and 2%. Coir fibre was procured from local market in Kakinada, East Godavari District. Coir used for the study was cut into 30 mm to 50mm length

V. RESULTS AND DISCUSSIONS

In the laboratory, various experiments were conducted by combination of different percentages of Copper slagand Silica fume in the lateritic soil. Compaction, CBR and

UCS tests were conducted with a view to determine the optimum combination of Copper slag and Silica fume. CBR and UCS are conducted for curing studies.

5.1 EFFECT OF COMBINATION PERCENTAGES OF RICE HUSK ASH (RHA) + METAKAOLIN (MK) AS ADDITIVES IN IMPROVING THE VARIOUS PROPERTIES OF PROBLEMATIC BLACK COTTON SOIL:-

The percentage of Rice Husk Ash was varied from 0%, to 9% with an increment of 3%. From the above graphs, it was observed that the treatment as combination with 9% rice husk ash + 6% metakaolin has moderately improved the Black cotton soil. It can be inferred from the graphs, that there is a gradual improvement in the Plasticity index improvement of about 28.7%. Also maximum dry density is improved by an amount of 9.8% and it was about 2.4 times i.e 140.24 % for UCS and 4 times i.e 300% for Soaked CBR respectively.

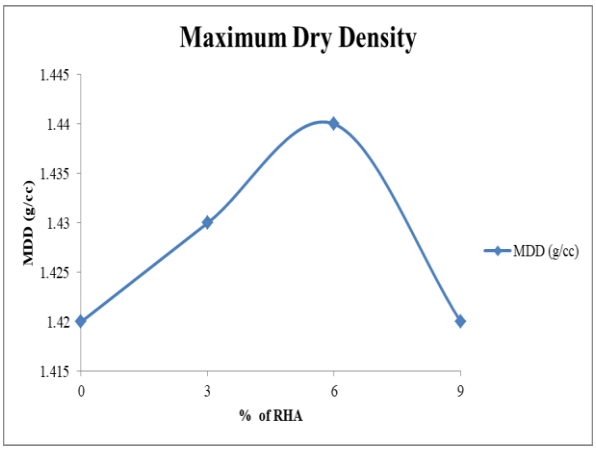

Fig 5.1 Plot showing the Variation in MDD with Addition of RHA to 0 % MK

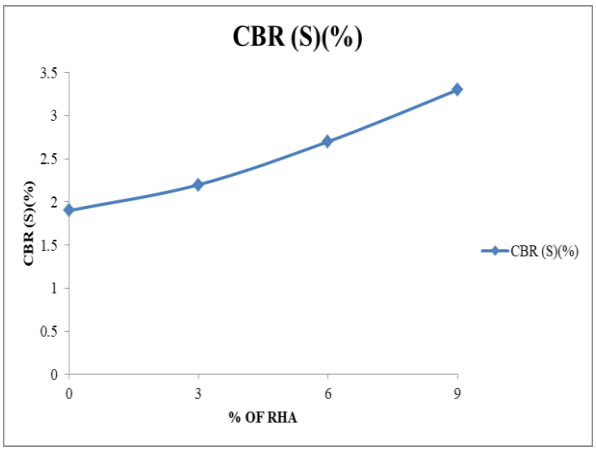

Fig 5.2 Plot showing the Variation in CBR VALUES with Addition of RHA to 0 % MK

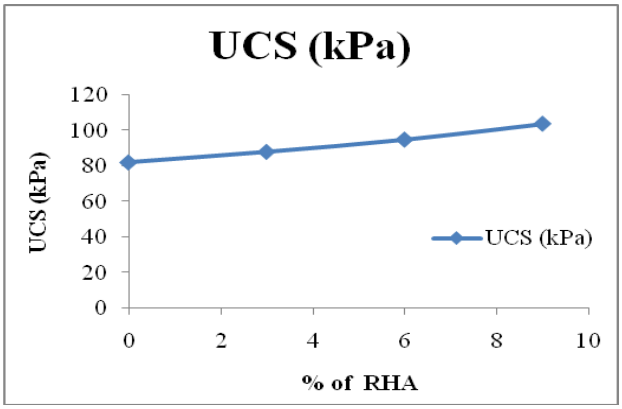

Fig 5.3 Plot showing the Variation in UCS with % Addition of RHA to 0 % MK

5.2 Results of the tests conducted on Black cotton Soil with different percentages of Rice Husk Ash to 3% Metakaolin

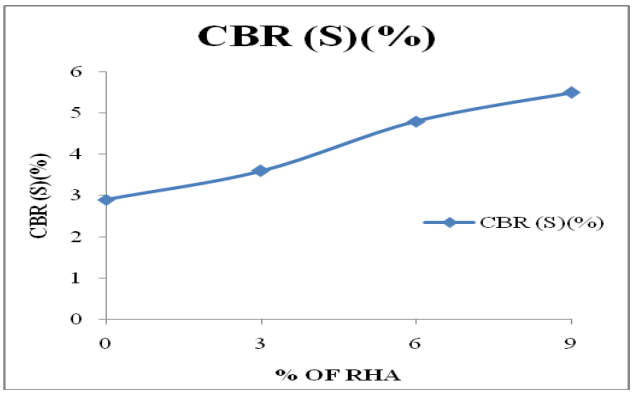

Fig 5.4 Plot showing the Variation in CBR VALUES with Addition of RHA to 3 % MK

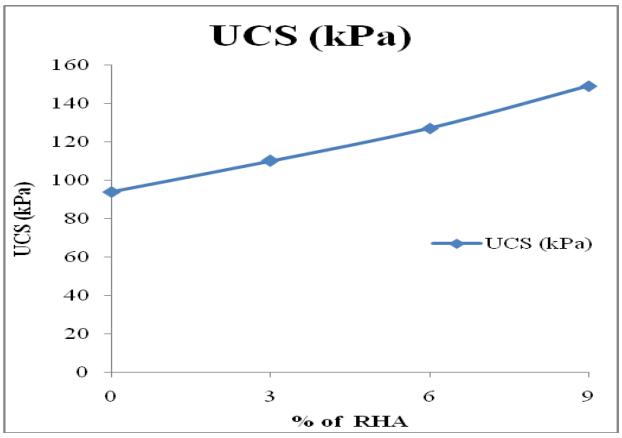

Fig 5.5 Plot showing the Variation in UCS with % Addition of RHA to 3 % MK

5.3 Results of the tests conducted on Black cotton Soil with different percentages of Rice Husk Ash to 6% Metakaolin

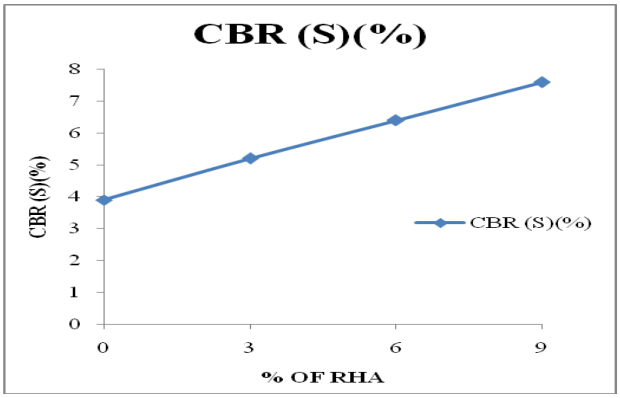

Fig 5.6 Plot showing the Variation in CBR with % Addition of RHA to 6% MK

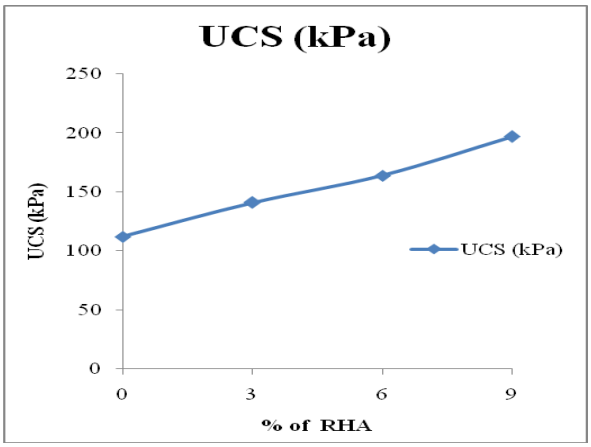

Fig 5.7 Plot showing the Variation in UCS with % Addition of RHA to 6% MK

5.4 Results of the tests conducted on Black cotton Soil with different percentages of Rice Husk Ash to 9% Metakaolin

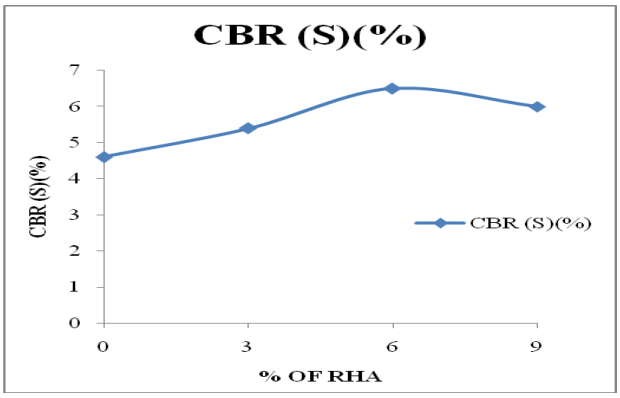

Fig 5.8 Plot showing the Variation in CBR with % Addition of RHA to 9% MK

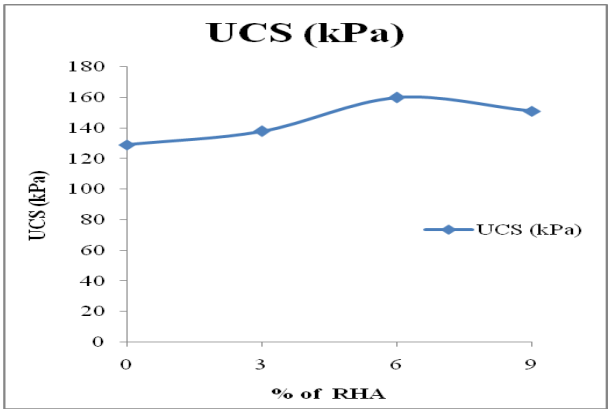

Fig 5.9 Plot showing the Variation in UCS with % Addition of RHA to 9% MK

It can be inferred from the above results from the above results, 9 % Rice husk ash (RHA) + 6 % metakaolin (MK) can be considered as optimum combination as additives in improving the various properties of problematic black cotton soil.

5.5 EFFECT OF COIR FIBRE ON THE PROPERTIES OF BLACK COTTON SOIL + RICE HUSK ASH AND METAKAOLIN

The influence of Coir Fibre on the Compaction CBR, UCS properties of weak Black cotton soil + 9 % Rice Husk Ash (RHA) + 6 % Metakaolin (MK) mixes are clearly presented in Figures for different percentages of coir fibre..

The percentage of Coir Fibre was varied from 0%, to 2 % with an increment of 0.5%.In the laboratory, tests were conducted by including different percentages of Coir Fibre to Weak Black cotton soil + Rice Husk Ash and Metakaolin .It is observed from the graphs, for the addition of 1.5% Coir fibre that there is an improvement in Maximum dry density is improved by an amount of 2.56% and it was about 16.24% for UCS and 17% for Soaked CBR respectively.

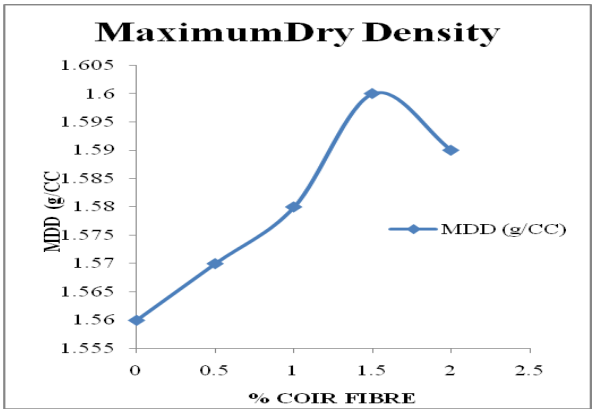

Fig 5.10 Plot showing the Variation in MDD with different percentages of CF with 9% RHA + 6% Metakaolin

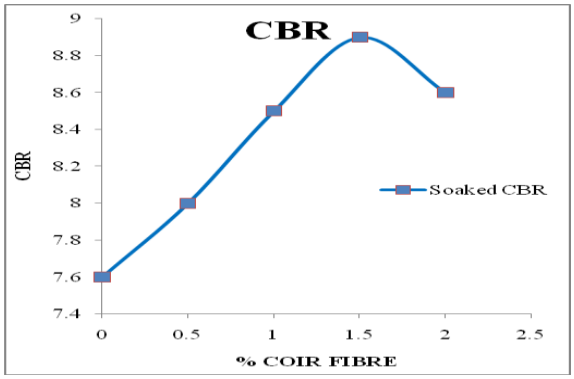

Fig 5.11 Plot showing the Variation in CBR with different percentages of CF with 9% RHA + 6% metakaolin Content

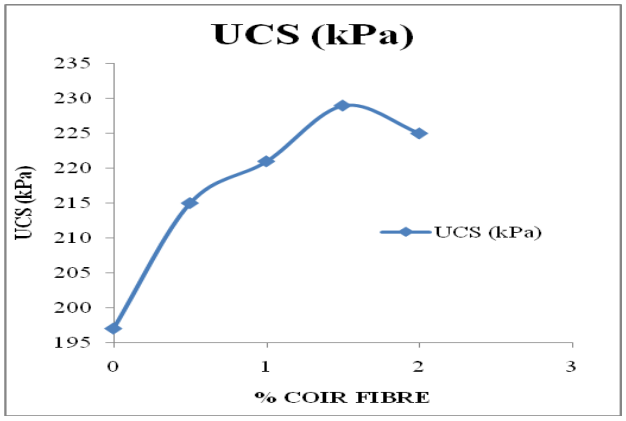

Fig 5.12 Plot showing the Variation in UCS with different percentages of CF with 9% RHA + 6% metakaolin Content

It can be inferred from the above results the optimum content of Coir fibre with 6% Metakaolin + 9% Rice husk ash as addition of black cotton soil is 1.5%

5.6 EFFECT OF CURING ON SAMPLES PREPARED WITH 1.5% COIR FIBRE + 6% METAKAOLIN + 9% RHA AS ADDITION OF BLACK COTTON SOIL

From the above results It is observed that samples prepared with 1.5% coir fibre + 6% metakaolin + 9% RHA as addition of Black cotton Soil and the graph shows increment of UCS and CBR values with increment of curing periods.

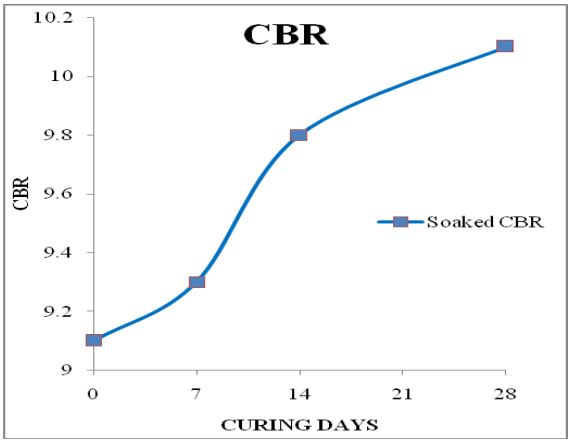

Fig 5.13 Plot showing the Variation in CBR at different curing periods

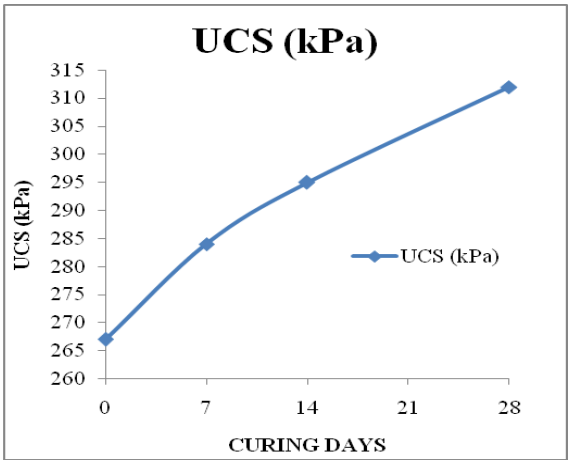

Fig 5.14 Plot showing the Variation in UCS at different curing periods

VI. CONCLUSIONS

The following conclusions are made based on the laboratory experiments carried out in this investigation.

- From the laboratory studies, it is observed that the Black cotton soil chosen was a problematic soil having high swelling, and high plasticity characteristics.
- It is observed that additives like rice husk ash and metakaolin improved strength of stabilized black cotton soil and made the stabilized mix more durable.
- It is noticed that the soil with a combined optimum dosage of 9% of Rice Husk Ash and 6% Metakaolin has moderately improved the properties of Black cotton soil.
- It can be inferred from the graphs, that there is a gradual improvement in the Plasticity index improvement of about 28.7%. Also maximum dry density is improved by an amount of 9.8% and it was

about 2.4 times 140.24% for UCS and 4 times i.e 300% for Soaked CBR respectively.

- There is an improvement in plasticity & Strength characteristics and 2.56% increment in maximum dry density with an increase in the Coir Fibre from 0% to 1.5% with an improvement of 0.5% for maximum dry density.
- There is an improvement by an amount of 16.24 % for UCS and 17 % for Soaked CBR respectively.
- From the results the Combined Optimum Content of rice husk ash + metakaolin for improving the black cotton soil is 9% rice husk ash + 6% metakaolin.
- It is evident that the addition of Rice Husk Ash and metakaolin to the Black cotton soil showed an improvement in properties to some extent and on further addition of coir fibre, the improvement was more pronounced.
- Finally it can be summarized that the materials Rice Husk Ash and Metakaolin and Coir Fibre had shown promising influence on the properties of Black cotton soil, thereby giving a two-fold advantage in improving problematic Black cotton soil and also solving a problem of waste disposal.

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