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USE OF COPPER SLAG AND RICE HUSK ASH TO STRENGTHEN THE ENGINEERING PROPERTIES OF BLACK COTTON SOIL

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Abstract - *Black Cotton (BC) soil stabilization has recently drawn the attention of several researchers. Copper slag (CS) and rice husk ash (RHA) have both been used in the past to stabilize black cotton soils. The authors attempted to stabilize BC soils using both of them at once. The goal of the current study was to compare how well various ratios of copper slag and rice husk ash performed as soil stabilizers. Black Cotton (BC) soil stabilization has recently drawn the attention of several researchers. Copper slag (CS) and rice husk ash (RHA) have both been used in the past to stabilize black cotton soils. The authors attempted to stabilize BC soils using both of them at once. The goal of the current study was to compare how well various ratios of copper slag and rice husk ash performed as soil stabilizers. California Bearing Ratio (CBR), Atterberg's limits, and compaction tests were conducted on the mixed proportion of BC soils, Copper Slag, and Rice Husk Ash. The use of copper slag and rice husk ash in combination for soil stabilization has only been the subject of a few researches. The maximum dry density of the treated soil changed just a little. The stabilized soil combinations have demonstrated good strength qualities and are suitable for use in low-cost construction projects such as building homes and constructing roads.*

Key words: *Atterberg's limit, California Bearing Ratio (CBR), Compaction test, Copper Slag, Rice Husk Ash.*

1.INTRODUCTION

Many civil engineering structures fail due to failure of soil underlying the structure for e.g. construction of buildings, dam, bridges, etc. Building foundations need to be on stable and strong soils. Expansive soils pose several problems to civil engineers and to geotechnical engineers. Expansive soils such as black cotton soil have the tendency to increase in volume when water is available and to decrease in volume if water is removed. Black cotton soil contains the clay mineral montmorillonite which is responsible for the excessive shrinkage and swelling characteristics of soil. These volume changes in swelling soils are the cause of many problems in structures that come into their contact or constructed out of them.

A large part of India is covered with black cotton soil. Black cotton soils are residual deposits formed from basalt. And are highly clayey soils and grayish to blackish in color. Some techniques are used for improving the strength of the soil and these are increasing the depth of the foundation, compacting the soil, replacing the soil under the foundation, and stabilizing the soil. Soil stabilization aims at improving soil strength and increasing resistance to softening by water through bonding the soil particles together, water proofing the particles or combination of the two. soil stabilization involves the use of stabilizing agents (binder materials) in weak soils to improve its geotechnical properties such as compressibility, strength, permeability and durability.

In recent times, with the increase in the demand for infrastructure, raw materials and fuel, soil stabilization has started to take a new shape. With the availability of better research, materials and equipment, it is emerging as a popular and cost effective method for soil improvement. One of the common approaches of subgrade stabilization is to remove the soft and replace it with a stronger material of crushed rock. The high cost of replacing has found forced highway agencies to evaluate alternative method for highway construction on soft subgrade. Pavement performance can be largely attributed to the performance of its foundation, which comprises of the subgrade and base layers. Base and subgrade layers must provide enough shear strength, stiffness modulus, resistance to moisture, stability and durability.

2. Literature Review

Sreekumar and Nair (2013) focused on the investigation for improving the properties of stabilized lateritic block with help of coir cutting waste utilized from coir industry as a reinforced material. The use of lateritic soil was done in the study which shows high clay content and was pre-stabilized with sand and cement, after this pre-stabilized block were prepared with further stabilizing with waste coir fibre and was tested for strength and durability. In his study he stabilized the soil with sand and cement, by making the block in the block making machine with varying percentages of sand and cement and curing them for 28 days, it was found that optimum results were obtained when the sand was 25% and the cement used was 8%. So, this was the reference used for the addition of coir fibre. The coir fibre content was varied in 0.5%, 1% and 1.50%. Now the block of soil-sand-cement- coir was made and tested for the optimum result in the laboratory.

Mittal et al. (2014) investigated the clayey soil with varying the percentages of coir fiber as 0.25%, 0.50%, 0.75% and 1% by weight. A series of unconfined compression test (UCS) and California bearing ratio (CBR) test were conducted in his study. From the study, it was found that there is considerable improvement in compressive strength of the soil reinforced with the coir fiber. Soil with no reinforcement had an unconfined strength of 2.75 kg/cm² which then on adding of fiber increased to a value of 6.33 kg/cm² for coir content of 1% by weight of soil, this increase in value could be because of increase in the shear parameters, it was found difficult to prepare the identical sample beyond 1% of fiber content so, only up to 1% of coir fiber was used in his study.

Jayasree et al. (2015) used coir waste which consists of coir pith and short coir fibers to study the change in the behavior of soil. For the experimental study, six different percentages of coir pith ranging from 0.5 to 3% were used and short fibre ranged from 0.2 to 1%. After the various tests, it was concluded that swell index reduced by 95% and 92% with the addition of coir pith and coir fibre respectively also the compression index was reduced by 68 and 94% respectively.

G. R. Ashwin Kumar et al. (2015) Marine clay is a type of clay found in coastal regions around the world. The most common problem in marine clay areas is the settlement and heave of house footings that are three feet deep or less. During dry periods, the soil loses moisture and shrinks which causing a gap under the footings. The house then settles resulting in cracked masonry walls, interior cracks in plaster, and warped door and window frames. Foundations that have settled during dry periods will often return to near the original position after rainfall replenishes the soil moisture causing the soils to swell again. After several cycles, the rebound of the foundation may become progressively less resulting in larger cracks. The main aim of this paper to improve the engineering characteristics of marine clay. Marine clay can be densified by mixing it with cement or similar binding material in specific proportions. In this paper Marine clay can be stabilized using copper slag. This method is usually adopted in highways where marine clay is used as a sub grade soil.

Parvathy S (2016) In this study copper slag is used as an additive. Copper slag is one of the waste materials that are being used extensively in the civil engineering construction industry. The test will be conducted based on the varying percentage of lime and copper slag with the clayey soil. The disadvantages of clay can be overcome by stabilizing with suitable material. Main laboratory tests include Un-confined compressive strength test (UCS), California bearing ratio test (CBR). This study is done to find out the engineering behavior of lime stabilized clayey soil with Copper Slag.

Das et al. (2016) studied about the shear strength parameters of the unreinforced and reinforced soil with coir fiber. A series of direct shear test were conducted at the normal stress of 0.5 kg/cm², 1.0 kg/cm² and 1.5 kg/cm². The coir fiber was added to the value of 1%, 2% and 3% by weight of soil. It was observed that the application of coir fiber on sand result in an increase in the shear strength parameters. The main cause for the improved shear strength is that in the absence of reinforcement the soil shows brittle failure but after the reinforcement, the soil starts showing the ductile Failure as the friction has now been developed between the soil and the reinforced material. Peter et al. (2016) investigated the behavior of soil which was stabilized with coir fibre and also the use of Coir pith was done in the study. Coir fibre was varied in content of 0.2%, 0.4%, 0.6%, 0.8% and 1% whereas the coir pith was varied from 0% to 3%. It was observed that with the inclusion of both coir pith and coir pith, the maximum dry density decreases and for OMC in the case of coir fibre was found decreasing initially which could be due to flocculation of clay particle when coir was added to them and again there was increase in an OMC with the further addition of coir fibre.

Bajaj et al. (2016) This paper presents the effects of Sugarcane Bagasse Ash and Core Fibre on, liquid limit, plastic limit, compaction characteristics and California Bearing Ratio on the black cotton soil. Design and construction of civil engineering structures on and with expansive soils is a challenging task for engineers. The present work is aimed to assess the improvement in the strength and stability characteristics in soft Subgrade soil by using the Sugarcane Bagasse Ash for the stabilization and then Core fibre as reinforcing material. Randomly distributed fibre reinforced soil (RDFRS) technique is used to prepare the reinforced soil samples. In RDFRS technique the mixing of reinforcement in the soil is very easy and no special skill is required. The reinforcement is added by percentage of the weight of the soil sample and by following certain aspect ratio i.e., length/diameter (L/D) ratio. Attempt is made to determine optimum combination of SCBA and core fiber content for maximum gain in strength.

Srikanth et al. (2017) Soil stability is some important criteria in the field of construction. For soil which lacks sufficient stability, various stabilization techniques can be adopted. Stabilization can increase the shear strength of soil and control the shrink-swell properties of soil, thus improving the load bearing capacity of the sub-grade to support pavements and foundations. A vast diversity of stabilization techniques exists. The focus of this report is to study the feasibility of stabilizing soil by using rice husk ash and coir fiber, thus re-using waste materials and providing an economical and ecofriendly method of soil stabilization.

Pooja et al. (2017) Tested the behavior of soil reinforced with Coir fibre with varying percentage form 0.5% to 1.5% by mass, it was observed that results from the UCS test for soil sample with fiber content of 0.5%, 1.0% and 1.5% unconfined compressive strength increased from the value starting from 11.68%, 1.26% and 0.62% respectively and concluded that reinforcing soil with fibers can be considered as good ground improvement technique especially in engineering projects on weak soils where it can act as a substitute to deep or raft foundation, reducing the total cost of project.

P. Bharath Goud et al. (2018) Present study was undertaken to evaluate the effectiveness of different percentages of rice husk ash and copper slag as soil stabilizers. The tests performed on the mixed proportion of BC soils, Copper Slag and Rice Husk Ash are Vane shear, California Bearing Ratio (CBR), Atterberg limits, free swell index (FSI), and compaction tests. Limited studies have been reported for the combination of copper slag and rice husk ash in soil stabilization. The optimum mix was found to be in the proportion of 64%BC+30%CS+6%RHA. FSI of soil treated with RHA+CS decreased steeply from 100% to 20.4%. There was a slight change in maximum dry density of the treated soil. The un soaked CBR test shows that strength of optimum mix was 12.7%. The stabilized soil mixtures have shown satisfactory strength characteristics and can be used for low-cost constructions to build houses and road infrastructure Laboratory vane shear tests have been carried out under undrained conditions to study the shear strength parameters of the stabilized soil.

Sharana Kumar et al. (2018) The objective of study is intended to decide the strengthening impact of haphazardly disseminated short polypropylene filaments on the California bearing ratio test and unconfined compressive strength of black cotton soil. The expansion of polypropylene stands brought about increment in Ideal dampness substance and decline in most extreme dry thickness. Copper slag is one of the waste materials that are being used broadly in the structure outline improvement. In this paper the stabilization is done to determine the effect of both polypropylene fiber and copper slag on engineering properties of black cotton soil. Here the dry density, CBR value and unified compression test were carried out. The proportions of copper slag used are (6%, 12%.18% and 24 %,) with respect to dry weight of the soil and also the proportion of polypropylene fiber used are (0.5%.1%, 1.5% and 2 %.) with the dry weight of the dirt. Then by mixing both polypropylene fiber and copper slag with proportion 0.5%, 1%, 1.5%, 2%, And 3%.6%, 9%, 12%, respectively with the dry weight of the soil. Karim et al. (2018) The main purpose of this study is to stabilize clay samples by mixing sawdust ash (SDA) at different concentrations (0%, 2%, 4%, 6%, 8% and 10% of dry soil weight). Studies have shown that the presence of clay causes the liquid limit and plasticity index of the soil affecting the soil. The addition of sawdust to fine clay improves the bulk and strength of the soil, as demonstrated by a decrease in specific and maximum dry density (MDD) as well as a decrease in compressibility (Can and Cr) and an increase in SDA. contents. Both the observed moisture content (OMC) and the undrained shear strength (cu) increased with increasing SDA concentration.

G. Ramachandran et al. (2019) The organic soils are unsuitable for construction works due to its low shear strength, high swelling potential and poor bearing capacity. These types of soils can be treated by stabilization and compaction methods. In this paper the study on effective use of stabilization using basalt fiber and ground granulated blast furnace slag (GGBS) in varying proportions and the main objective of this study is to increase the geotechnical properties of soil. The study has been conducted with three different proportions of basalt fiber as 1%, 2%, 3% and ground granulated blast furnace slag as 3%, 6% and 9%. The reinforced soil where subjected to compaction and unconfined compressive test (UCS). The experimental results have shown effective increment in compressive strength and shear strength of the soil.

Adla Prathyusha et al. (2020) Heavy structures such as highways, bridges, highway embankments need good foundation soil. The use of natural or man-made fibers in sub grade soils is one of soil improvement technology for heavy projects. Basalt fibers is a naturally obtained inorganic fibers material which has wide use in many industries. Now-a-days the use of basalt fibers in concrete or soil was increased due to its excellent mechanical and environmental friendly properties. On other hand Telangana has a highest red soil deposit which has sand as major composition. Therefore, in this study an attempt is made to find the suitability of locally obtained red soil with the addition of basalt fibers for highway construction. The stabilized soil (soil + basalt) sample is tested for understanding the polypropylene characteristics through resilient and California bearing ratio (CBR) properties. Different percentages of basalt fibers (0%, 0.2%, 0.4%, 0. 6%, 0.8%, 1%, 1.2% and 1.4%) by weight of raw soil is added to the conventional red soil. Stabilized soil was subjected to California bearing ratio (CBR) and proctor compaction test along with preliminary tests. The experimental results show that the addition of basalt fiber effectively increasing the strength of the soil. Adding of basalt fiber around 0.8% (by soil weight) can significantly enhance the strength of sub grade soil and efficiently improves in the design of pavement structure for highways.

Chandrakaran et al. (2021) The studies used soil that had only been treated with fly ash and nylon fiber. First, the methods used to determine the ideal fly ash that may be employed in untreated soil. In addition, different amounts of nylon fiber (0.25 and 0.5) were applied at different fly ash percentages (10, 20, 30 and 40), and the ideal was discovered. To determine the optimal percentage, a supervised test was performed and strength was measured using a compressive strength test. The optimum nylon fiber and fly ash (from heavy soil) are 0.25 percent and 20 percent, respectively. The effect of positive percentage on the compressive strength and plastic properties of cultivated soil was tested at application periods of 1 day, 7 days and 28 days. This study shows that the strength of the soil stabilized with nylon fibers and fly ash increases, and the soil tillage strength also increases in the case of the combination of fly ash and nylon fibers.

Manish Kumar Jha et al. (2022) The primary objective of this work is to study the interaction of black cotton soils with Copper Slag and GGBS. To improve the Geo-Technical and Engineering Properties of the Black- Cotton soil. To study the behavior of strength, gain in black cotton soil using Copper Slag and GGBS Stabilization. Kumar et al. (2023) This study aims to determine how the mixture of sawdust ash and rice husk ash affects the electrical properties of black cotton. For all mixed models, different concentrations of rice husk ash of 0, 3, 6, 9, 12 and 15% (based on the weight of black soil) were added to the soil compared to sawdust ash at 6% by weight of the soil. cotton soil. To evaluate the electrical properties of soils and their mixtures, tests such as Attenberg Limit, Specific Gravity, Particle Size Distribution, Standard Proctor Test, Unconstrained Compressive Strength (UCS) and California Bearing Ratio (CBR) are performed. The results showed that the addition of 9% wheat hull and 6% wood ash greatly improved the electrical properties of black cotton.

RESEARCH GAP

On clayey soil, enough study has previously been conducted utilizing Copper Slag and Rice Husk Ash separately. However, no studies have yet been done to determine how Copper Slag and Rice Husk Ash perform on clayey soil. Regarding other soil types, such clayey soil, we haven't yet examined how they stabilize the soil. This study is an experimental program that uses CBR, compaction testing, and unconfined compression experiments to examine the effects of Copper Slag and Rice Husk Ash on clayey soil.

3. Materials and Methodology

3.1 Materials Used

The various material used:

1. Black Cotton Soil
2. Copper Slag
3. Rice Husk Ash

3.1.1 Soil: The soil collected from the site was pulverized to break the lumps with wooden hammer and then dried in air under covered area. Then it was sieved through 2.35 mm IS sieve and mixed thoroughly. For each test required quantity of soil was taken from polythene bags and dried in an oven at 105° C ± 5°C for 24 hours. The soil was allowed to cool at room temperature.

Table 3.1.1 Properties of soil used in the study

S.NO.	PROPERTIES	RESULTS
1	Liquid Limit	40 %
2	Plastic Limit	23 %
3	Plasticity Index	17 %
4	Optimum Moisture Content	14.25 %
5	Maximum Dry Density	17.31 kN/m³
6	Specific Gravity	2.67
7	CBR (%) (soaked)	2.8 %
8	CBR (%) (Unsoaked)	4.2 %
9	U.C.S	170.62 kN/m^2
10	Indian Soil Classification	CI

3.1.2 Copper Slag: Copper slag was collected from the Air blast equipment India Pvt. Ltd. Hyderabad the shade of the copper slag is dark, smooth, utilized as a part of the examination.

Table 3.1.2 Chemical Composition of Copper Slag

S.NO.	COMPOUND	VALUE %
1	SiO2	25-35
2	Al2O3	2-9
3	Fe2O3	45-55
4	CaO	1-3.5
5	MgO	1-5
6	So3	0.11
7	K2O	0.61

3.1.3 Rice Husk Ash: The husk of the rice Burning rice husk, a byproduct of paddy rice milling, results in ash. For this study endeavor, RHA was obtained from adjacent mills.

Table 3.1.3 RHA physical and chemical characteristics

Rice husk ash (RHA)	
Index Property	**Index Value**
Water content (W)	83.3 %
Specific gravity (G)	2.0
SiO3	81.2 %
Al 2O3	6.01 %
Fe 2O3	0.08 %
CaO	0.75 %
MgO	0.91 %
SO3	0.42 %
Na 2O	0.13 %

3.2 METHODOLOGY

Utilizing industrial wastes like Copper Slag and Rice Husk Ash in the current project might be effective in the construction of low-cost rural roads and stabilize the subgrade of pavements when the soil is expansive in character. On the samples chosen for investigation, these several tests must be run:

1. Using Cassegrande's apparatus, the liquid limit test and plastic limit test must be performed first on virgin soil and then on various mixing ratios. The plasticity index of the optimum mix should always be lower than that of virgin soil.

2. Using the Standard Proctor Test, the maximum dry density (MDD) and optimum moisture content (OMC) of virgin soil are determined, and the MDD of the mix proportions is compared. The MDD of the ideal mixture must always be greater than that of pure soil.

3. In order to obtain CBR values at different material proportions, a California bearing ratio test is conducted.

4. Unconfined compression strength tests are performed to determine UCS values at various material proportions.

4. RESULTS

After the soil was oven dried, following basic tests were performed on it:

- Atterberg's limit analysis (IS: 2720 Part V-1985)
- Specific Gravity Test (Pycnometer test) (IS: 2720 Part III-Section I/II-1980)
- Standard proctor test (IS: 2720 Part VII-1980)
- California bearing ratio test (IS: 2720 Part XVI-1987)
- Unconfined compressive strength test (IS: 2720 Part X-1991)

4.1 Standard Procter Test

4.1.1 Untreated Soil and Copper Slag Mix

Table 4.1.1: Results of OMC and MDD for untreated soil and CS mix

SOIL:CS	MDD (kN/m³)	OMC (%)
100:0	17.31	14.25
90:10	16.90	14.80
80:20	16.30	15.46
70:30	15.86	16.10

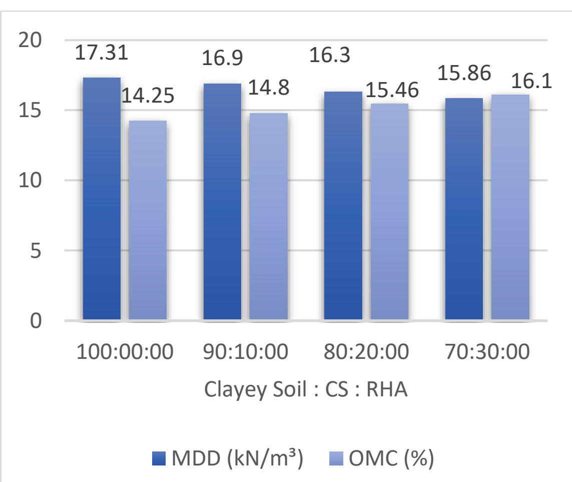

Fig.: - 4.1.1 Showing variations b/w MDD and OMC of CS & soil with different proportions

4.1.2 CLAYEY SOIL AND RICE HUSK ASH MIXES

Table no. 4.1.2: Results of OMC and MDD for mix proportions of Soil and Rice Husk Ash

SOIL:RHA	MDD (kN/m³)	OMC (%)
100:00	17.31	14.25
95:05	17.10	14.55
90:10	16.75	14.92
85:15	16.40	15.20

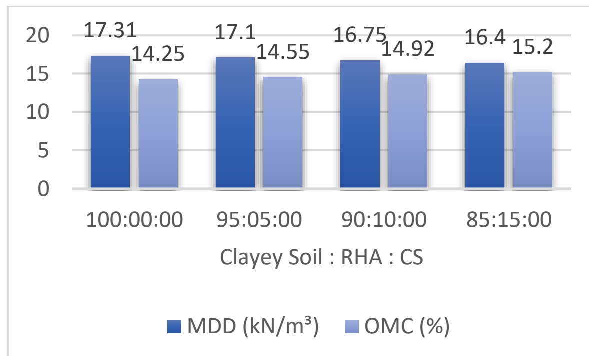

Fig: -4.1.2 Showing variations b/w MDD and OMC of RHA & soil with different proportions

4.1.3 CLAYEY SOIL, COPPER SLAG AND RICE HUSK ASH MIXES

Table no. 4.1.3: Results of OMC and MDD for mix proportions of Soil, CS and RHA

SOIL:CS:RHA	MDD (kN/m³)	OMC (%)
100:00:00	17.31	14.25
85:05:10	16.80	14.70
80:10:10	16.40	15.34
75:15:10	15.90	16.20

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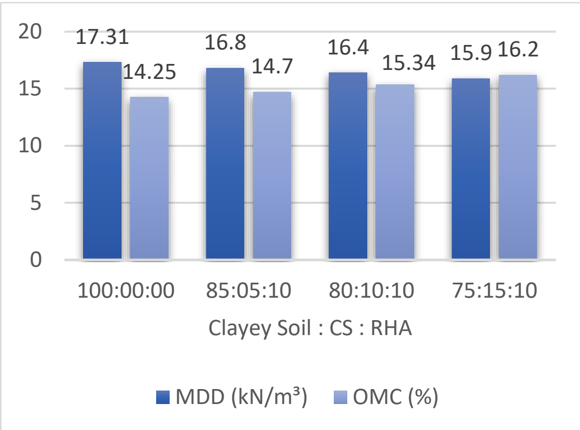

Fig 4.1.3: - Showing variations b/w MDD and OMC of Copper Slag, RHA & soil with different proportions

4.2 UNCONFINED COMPRESSION STRENGTH TEST

Table 4.2.1: Results of UCS Test of virgin soil

Clayey Soil	Curing Period (Days)	UCS kN/m^2
100:00:00	7	170.62

Table 4.2.2: Results of UCS of Copper Slag

Clayey Soil : CS	Curing Period (Days)	UCS kN/m^2
100:00:00	7	170.62
90:10:00	7	310.11
80:20:00	7	375.45
70:30:00	7	430.19

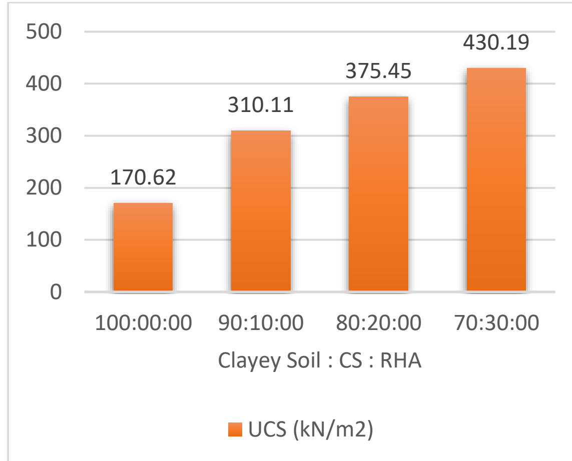

Fig: -4.2.2 UCS Graph of Copper Slag & soil with different proportions

Table 4.2.3: Results of UCS of Rice Husk Ash

Clayey Soil : RHA	Curing Period (Days)	UCS kN/m^2
100:00	7	170.62
95:05	7	240.68
90:10	7	292.52
85:15	7	336.69

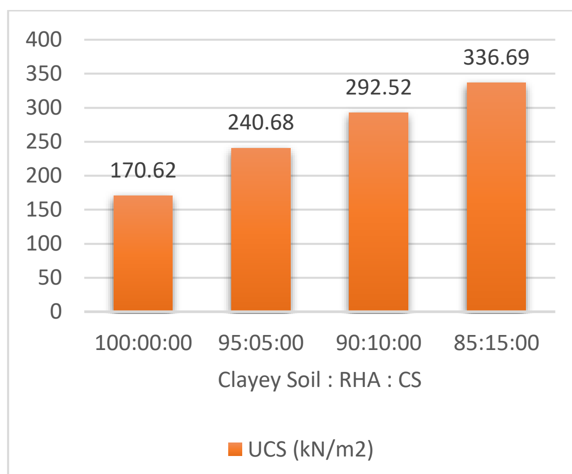

Fig: -4.2.3 UCS Graph RHA & soil with different proportions

Table 4.2.4: Results of UCS of Copper Slag and Rice Husk Ash with Soil

Clayey Soil : CS : RHA	Curing Period (Days)	UCS kN/m^2
100:00:00	7	170.62
85:05:10	7	330.47
80:10:10	7	410.87
75:15:10	7	480.52

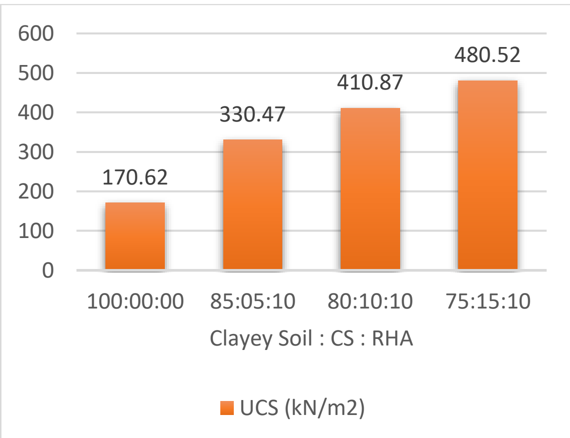

Fig: -4.2.4 UCS Graph Copper Slag, RHA and soil with different proportions

4.3 CALIFORNIA BEARING RATIO TEST

Table 4.3.1: Results of CBR value for clayey soil sample.

Clayey Soil	CBR (%) Soaked	CBR (%) Un soaked
100:00:00	2.8	4.2

Table 4.3.2: Results of CBR of Copper Slag

Mix Proportions (Soil : CS)	CBR (%) Soaked	CBR (%) Unsoaked
100:00	2.8	4.2
90:10	4.3	6.45
80:20	5.4	7.56
70:30	6.1	8.54

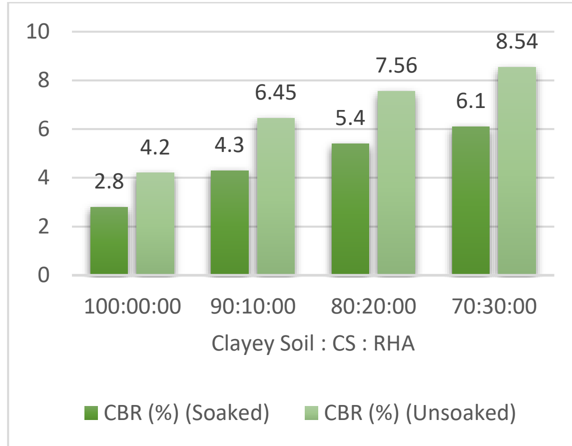

Fig: -4.3.2 CBR Graph of Soil and Copper Slag with different proportions

Table 4.3.3: Results of Soil and Rice Husk Ash

Mix Proportions (Soil : RHA)	CBR (%) Soaked	CBR (%) Un soaked
100:00	2.8	4.2
95:05	3.7	5.18
90:10	4.6	6.44
85:15	5.3	7.42

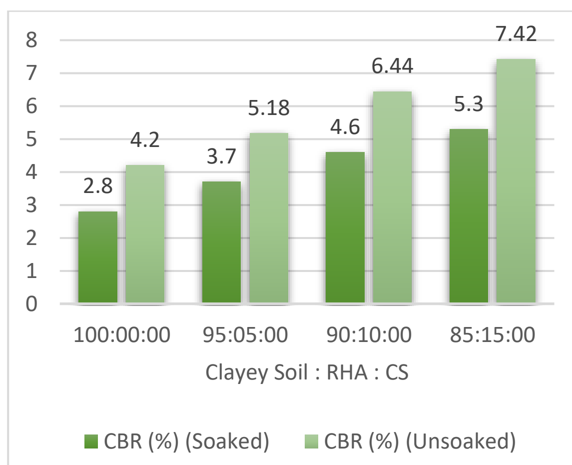

Fig: -4.3.3 CBR Graph of Soil and Rice Husk Ash with different proportions

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Table 4.3.4: Results of CBR of Soil, Copper Slag and Rice Husk Ash

CS : CS : RHA	CBR (%) Soaked	CBR (%) Un soaked
100:00:00	2.8	4.2
85:05:10	4.5	6.75
80:10:10	5.7	7.98
75:15:10	6.4	8.96

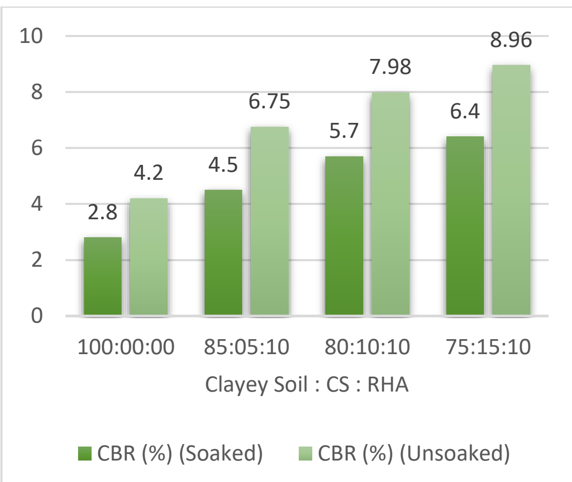


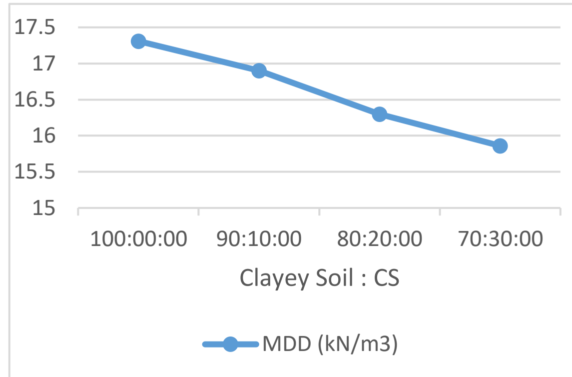
Fig: -4.3.4 CBR Graph of Soil, Copper Slag and Rice Husk Ash with different proportions

5. Discussions

5.1. Compaction Test

Compaction characteristics of soil have been evaluated in this study by using different percentages of Copper slag. A decrease in MDD was noted with the increase in Copper slag percentage. This may happen because the specific gravity of Copper slag is lower as compared to soil. However, there is increase in optimum moisture content when quantity of Copper slag is increased. This may take place because of the pozzolanic reaction of Copper slag with soil that requires more water for completion of cation exchange reaction. Moisture requirement for wetting the large surface area of Copper slag for thick packing of the soil is also more. The variation in MDD with Copper slag and variation in OMC with Copper slag is shown below in figure no. 5.1.1 and 5.1.2.

Fig. no. 5.1.1



Variation in MDD with increase in Copper slag percentage

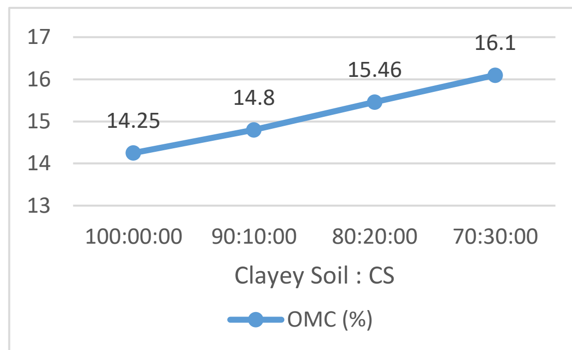


Fig. no. 5.1.2 Variation in OMC with increase in Copper slag percentage

With Copper slag different ratios, MDD decreases with an increment in Rice Husk Ash content in mixture of soil and RHA. The variation of MDD with increment in Copper Slag content and variation of OMC with increment in RHA content is shown below in figure no. 5.1.3 and 5.1.4.

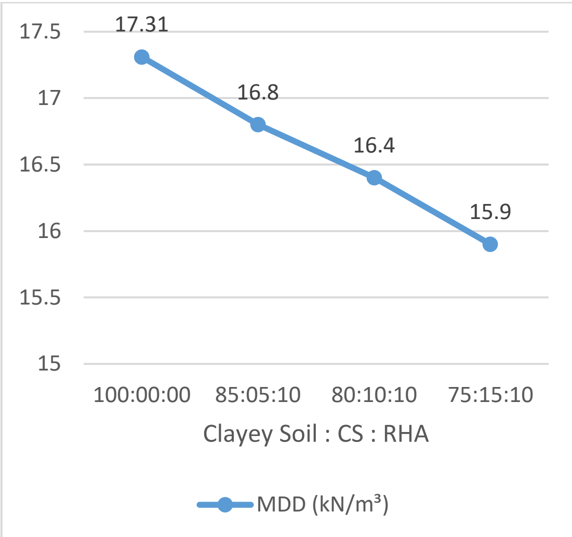


Fig no. 5.1.3 Variation in MDD with increase in copper slag and RHA content

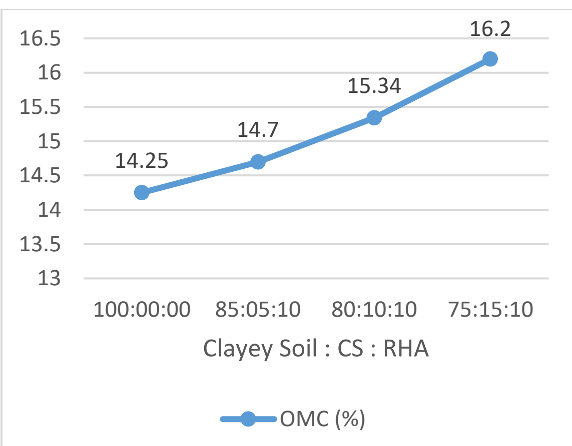


Fig no. 5.1.4 Variation in OMC with increase in copper slag and Basalt fibre content

5.2 California Bearing Ratio Test

The soaked CBR values of soil sample improve marginally when Copper slag is added. The soaked CBR value improved with increment in Copper slag (15%) and Rice Husk Ash (10%). The increment in CBR value may be due to the formation of cementitious compounds in the soil by the reaction between the pozzolonic compounds of Copper slag and CaOH available in soil. With 15% Copper slag and RHA 10% as optimum quantity. The relationship between CBR value, Copper slag and RHA percentage is as shown in figure 5.2.1.

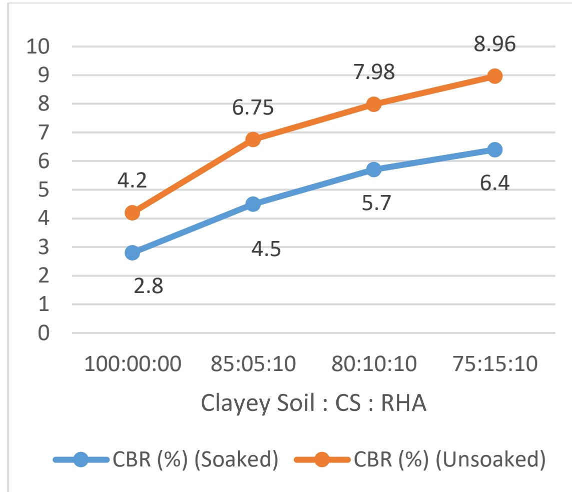


Fig. no. 5.2.1 Variation in CBR value with increase in CS and RHA content

5.3 Unconfined Compression Strength Test

The UCS value of virgin soil also improves considerably with expansion of Copper slag (15%) and Rice Husk Ash (10%). The value increases with addition of Copper slag and RHA. The reason behind of this when Copper slag and RHA comes in contact with water, pozzolanic reactions takes place during the curing period.

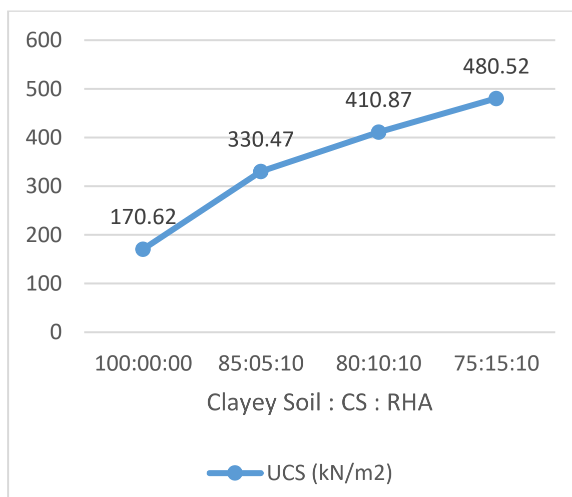


Fig. no. 5.3.1 Variation in UCS value with increase in CS and RHA content

6. Conclusions

Following conclusions can be inferred on the basis of the experiments performed:

1. Copper slag is a waste product which can be effectively used in the stabilization process of soil due to its cementitious properties that helps in increasing the strength of soil.

2. Rice Husk Ash on the other hand is a cheaply available material which can be added to soil in less quantity to make big changes in its strength parameters.

3. The value of Copper Slag is used for this work was 15% because of the optimum value of C.B.R. is found at 15% of when Copper Slag added to soil.

4. The C.B.R value increases with increase of Rice Husk Ash along with fixed quantity of Copper Slag. It increased 2.28 times from the untreated soil.

5. The optimum value of Copper Slag and Rice Husk Ash required for soil stabilization is 15% and 100% by weight of soil respectively.
6. Unconfined compressive strength increases with increase of quantity of Copper Slag and with fixed quantity of Rice Husk Ash. The value of unconfined compressive strength is increased 2.81 times from the untreated soil.

References

1. Divine Ingabire and Sanjeet Kumar (2023) "Enhancement of Engineering Properties of Black Cotton Soil Using rice husk and sawdust ash" ICMED-ICMPC 2023, E3S Web of Conferences 391, 01023 (2023).

2. Zuhaib Zahoor Shawl, Er. Ved Parkash (2017) "Use of lime and Saw Dust Ash in soil stabilization". International Journal of Innovative Research in Science, Engineering and Technology". Vol. 6, Issue 2, February 2017.

3. Wajid Ali Bhutt, Karan Gupta and J.N Jha (2016) "Strength behavior of clayey soil Stabilized with Saw Dust Ash". International Journal of Geo-engineering.

4. C.V Nilna, S. Chandrakaran (2021) "stabilization of soft clay using nylon fibre and fly ash". Springer (lectures notes of civil engineering) 28 July 2021.

5. F. Okonta, Innocent kafodya (2018) "Effects of natural fiber inclusions and pre-compression on the strength properties of lime-fly ash stabilized soil" Elsevier (Construction and building materials) Volume 170, 10 May 2018, Pages 737-746

6. Ahmed Mancy Mosa, Amer Hasan Taher, Layth A. Al-Jaberi (2017) "Improvement of poor subgrade soil using cement kiln dust".

7. B.R. Phanikumar, Ravideep Singla (2016) "Swell-consolidation characteristics of fibre reinforced expansive soils".

8. Dr. Siddhartha Rokade, Rakesh Kumar, Dr. P.K. Jain (2017) "Effect of Inclusion of Fly-Ash and Nylon Fiber on Strength Characteristics of Black Cotton Soil". EJGE Vol. 22 [2017].

9. Hesham A. H. Ismaiel (2013) "Cement Kiln Dust Chemical Stabilization of Expansive Soil Exposed at El-Kawther Quarter, Sohag Region, Egypt".

10. M. Heeralal, G.V. Praveen (2011) "A study on effect of fiber on cement kiln dust stabilized soil". JERS/Vol. II/ Issue IV/October-December, 2011/173-177

11. M.K. Rahman, S. Rehman & O.S.B. Al- Amoudi (2011) "Literature review on cement kiln dust usage in soil and waste stabilization and experimental investigation".

12. Kameshwar Rao Tallapragada, Anuj Kumar Sharma, Tarulata Meshram(2009) "laboratory investigation of use of synthetic fibers to minimize swell in expansive subgrades". IGC 2009, Guntur, INDIA

13. Pallavi, Pradeep Tiwari, Dr P D Poorey (2016) "Stabilization of Black Cotton Soil using Fly Ash and Nylon Fibre". IRJET Volume: 03 Issue: 11 | Nov -2016

14. Indian Standard Code IS 2720-16, IS 2720-10.

15. C.C. Ikeagwuani, I.N. Obeta and J.C. Agunwamba, "Stabilization of black cotton soil subgrade using sawdust ash and lime," SF, 59(1), 162-175, February (2019).

16. N. Talukdar, K. D. Dkhar, and K. Talukdar, "The Effect of Rice Husk Ash and Saw dust on the Engineering Properties of Soil," IJIRS, 1-11, (2016).

17. T.R. Karatai, J.W. Kaluli, C. Kabubo and G. Thiong'o, "Soil Stabilization Using Rice Husk Ash and Natural Lime as an Alternative to Cutting and Filling in Road Construction," JCEM, 143(5), May (2017).

18. S. Ayuba, O. U. A. Uche, S. Haruna and A. Mohammed, "Durability Properties of Cement – Saw Dust Ash (SDA)

Blended Self-Compacting Concrete (SCC),"NIJOTECH, 41(2), 212 –221, March 2022.

19. E.A. Oshioname, Y. Paul, A. Mustapha and A.A. Abdullahi "Consolidation Characteristics of lateritic Soil Treated with Rice Husk Ash," MJCE, 34(1), 19–28, March (2022).

20. M.A.Q. Adajar, C.J.P. Aquino, J.C.D. Dela, C.P.H. Martin and D.K.G. Urieta,"Investigating The Effectiveness of Rice Husk Ash as Stabilizing Agent of Expansive Soil," IJ of GEOMATE, 16(58), 33 - 40, June (2019).

21. G. Ramachandran (2019) "experimental study on soil stabilization using basalt fiber and ground granulated blast furnace slag in organic soil". International Journal of advance and Research and innovation. Volume: 06, Issue: 04. ISSN 2347-3258.

22.Adla Prathyusha, Harish kumar (2020) "Experimental Study on the Suitability of Basalt Fiber Reinforced Red Soil for Highway Construction". 2020 IJRTI | Volume 5, Issue 1 | ISSN: 2456-3315.

23. P.Bharat Goud (2018) "Stabilization of Black cotton soil with Copper slag and Rice husk ash- An Environment Approach". International Journal of Science and Research(IJSR). ISSN(online) 2319-7064, ICV 79.57.

24. Sharana Kumar B.M (2018) "the Use of copper slag and Polypropylene fibre to strengthen the engineering properties of soil". International Research Journal of Engineering and Technology (IRJET), e-ISSN: 2395-0056, Volume: 05, Issue: 06, p-ISSN: 2395-0072

25. Pooja Upadhyay, Yatendra singh (2017) "Soil stabilization using natural coir fiber". International Research Journal of Engineering and Technology (IRJET), e-ISSN: 2395-0056, Volume: 04, Issue: 12, p-ISSN: 2395-0072.

26. Jheelu Bajaj, Vikash kumar singh (2016) "Performance Evaluation of Block Cotton Soil Stabilized with Sugarcane Bagasse Ash and Randomly Distributed Core Fibres". IJIRST –International Journal for Innovative Research in Science & Technology, Volume 2, Issue 11, April 2016 ISSN (online): 2349-6010.

27. Anil kumar Sharma, P.V. Sivallaiah (2016) "Ground granulated blast furnace slag amended Bagasse Ash as an expansive soil stabilizer". Soil and Foundations.

28. Abhijith R.P. (2015) "Effect of Natural Coir fibers on CBR Strength of Soil Sub grade". International Journal of Scientific and Research Publications, Volume 5, Issue 4, April 2015.

29. Ayininuola G.M. and Oladotun P.O. (2016) "Geotechnical Properties of Coconut Coir Fibre Soil Mixture ". Journal of Civil Engineering Research, 6(4), pp.79-85.

30. Bose B (2012) "Geo engineering properties of expansive soil stabilized with Bagasse Ash", Electronic Journal of Geotechnical Engineering, Vol. 17, Bund. J, 2012, pp. 1339-1353.

31. Consoli, N. C., Prietto, P. D. M. and Ulbrich, L. A. (1999) ''the behavior of a fiber- reinforced cemented soil.'' Ground Improvement, London, 3(1), 21–30. IS 2720 – part (xiii) 1980-87 I

32. Gyanen. Takhelmayum, Savitha.A.L, Krishna Gudi (2013) — Laboratory study on soil stabilization using Bagasse Ash mixtures, International Journal of Engineering Science and Innovative Technology (IJESIT) Volume 2, Issue 1.

33. Jain, A. and Puri, N. (2013). Consolidation characteristics of highly plastic clay stabilized with rice husk ash. International Journal of Soft Computing and Engineering (IJSCE), 2.

34. Kaushal Kumar et. al. Characteristics of Bagasse Ash in Relation of Soil Amendment. Materials today proceedings, Volume 4, issue 2-part A

35. Mahmood R. Abdi, Ali Parsapajouh, and Mohammad A. Arjomand, (2008), "Effects of Random Fiber Inclusion on Consolidation, Hydraulic Conductivity, Swelling, Shrinkage Limit and Desiccation Cracking of Clays", International Journal of Civil Engineering, Vol. 6, No. 4, (284-292).

36. Marity, J.; Chattopadhyay, B. C. and Mukherjee, S. P. 2012. Behavior of sands mixed randomly with natural fibers. In: EJGE. 17: 1833-1854.

37. Malekzadeh, M. and Bilsel, H. 2012. Swell and compressibility of fiber reinforced expansive soils. International Journal of Advanced Technology in Civil Engineering. 1(2): 42-46.

38. Priyank Goyal, Ashutosh Shankar Trivedi, Manoj Sharma (2015) "Improvement in Properties of Black Cotton Soil with an Addition of Natural Fibre (Coir) Derived from Coconut Covering" International Journal of Engineering Research and Applications (IJERA), Vol:5 Issue No:3, 36-37.