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SOIL STABILIZATION OF BLACK COTTON SOIL USING LIME AND WOOD ASH

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Abstract - *Soil stabilisation is the process used for improving strength properties of soil. In india because of different tropographical regions, improving soil strength is now a difficult task. In the current study, black cotton soil stabilisation was accomplished using resources that were readily available in the area. The impact of lime and wood ash on the black cotton soil was examined in current study. Lime is widely used to stabilise black cotton soil, but further research is needed to determine how lime and wood ash interact. Lime and wood ash were combined to create 24 soil samples at various percentages. This study focuses on improving the physical properties of black cotton soil by stabilising its atterberg limits, standard proctor, unconfined compressive strength and California bearing ratios in accordance with Indian standards. Variation of lime, wood ash was separately and combined in study was investigated, with replacement rates of 2 %, 4 %,6 %, up to 8 %, and 8 %, 16 %, up to 24 %, respectively. When lime was added, it was found that OMC increased while MDD reduced. When the two were combined, OMC marginally increased while MDD also somewhat decreased. In both instances, the increment in CBR value tends to rise up to the optimum value and then begin to fall after it. The greatest increase in the lime case was 266.92 %. Additionally, when both additions were employed in various combinations, the ideal ratio of 6% lime and 16 % wood ash was discovered, increasing the CBR value by 594% . The UCS value of virgin black cotton soil, which was 191.7 kN/m², increased to roughly 414.9 kN/m² for lime (6 % optimum). The optimal ratio of lime and wood ash (6 % and 16 %, respectively) in black cotton soil had a noticeable impact (514.5kN/m²) on the soil's UCS value.*

Key Words: Black cotton soil , Lime, Wood Ash, OMC&MDD,UCS,CBR.

1. INTRODUCTION

The strength of the foundation decides whether it will not Heavy clay soil, often known as black cotton soil, can range in colour from light to dark grey and can be either clay or loam. With soil like this, cotton can grow In general, the central and southern regions of India have the best soil. It is a basalt-derived residual soil that has undergone chemical weathering and contains a significant amount of the clay mineral montmorillonite. Black cotton soil, which are mainly unconnected to the immediate impact of loading by the structure, is a geotechnical engineering term. Due to its volumetric variations, black cotton soil is unsuitable for use in building With a change in water content, it abnormally swells and contracts. Due to the small clay driblets present, that expand as come into touch with water, the soil has this propensity to alternately swell and contract, which causes differential settlement of structures.

Consequently the stabilization for In this research, lime and wood ash have been used to stabilize the black cotton soil. Reduced soil permeability and compressibility are further benefits of soil stabilization. Any inexpensive substance with cementitious qualities is used to stabilise the soil, which lowers the cost of construction. Because of its low permeability and compressibility, strong swelling property, and other unfavourable characteristics, BCS is regarded as one of the least acceptable soils for engineering projects., This soil is extremely tough to work with due to its highly plastic character. BCS is stabilised using a variety of techniques, including lime, mechanical stabilisation, and chemical stabilisation. There are numerous stabilising substances that are employed in both mechanical and chemical stabilisation.

1.1 MATERIAL USED FOR THIS STUDY

BLACK COTTON SOIL

They are soft, extremely expansive soils that have a high tendency to contract or expand in response to changes in moisture. During dry seasons, the rigorous swelling-shrinking tendencies cause openings in the surface cracks. Due to their dark brown appearance and appropriateness for cotton cultivation, they are sometimes referred to as "Black Cotton Soils" in popular culture. They are black because of iron and aluminium compounds. The central and southern regions of India have the best soil. It is a basalt-derived residual soil that has undergone chemical weathering and contains a significant amount of the clay mineral montmorillonite. It has a dark colour and is suitable for growing cotton. It exhibits great plasticity, high compressibility, high swelling shrinkage, and low shear strength. There is a lot of clay in the black cotton soil. Chemically, soils for black cotton are composed of lime, iron, magnesium, alumina, and potash, but they are deficient in organic matter, nitrogen, and phosphorus. They

are useful for cotton farming due to their ability to retain water. The name "black cotton soil" was chosen.

Table -1: Engineering properties of black cotton soil

Sr. No.	Properties	Values
1.	Soil Classification	CH(Highly compressible)
2.	Liquid Limit (LL)	68%
3.	Plastic Limit (PL)	25.3%
4.	Plasticity Index(PI)	45%
5	Specific Gravity	2.58
6	Unconfined Compressive Strength(UCS)	191.7kN/m^2
7	Optimum Moisture Content (OMC)	14%
8	Maximum DryDensity (MDD)	18.53kN/m^3
9	California Bearing Ratio (CBR)	2.79%

LIME

Lime known for its large concentrations of calcium and/or magnesium carbonate, dolomite (calcium and magnesium carbonate), and only trace amounts of other minerals, limestone is a naturally occurring and widely distributed sedimentary rock. All across the world, it is taken out of quarries and underground mines. The technique of adding lime to black cotton soil to increase its features like density, bearing capacity, and Improvement in strength, greater resistance, permanent deformation, lowers swelling, and resistance to moisture, is one of the finest methods for soil stabilisation. The main components of lime, an inorganic calcium-containing substance, are oxides and hydroxides, typically calcium oxide and/or calcium hydroxide.

Table-2 Composition of Lime

S.No	Chemical Composition	Percentage
1	Calcium oxide, CaO	75.22
2	Aluminium oxide,Al_2O_3	0.12
3	Magnesium oxide, MgO	0.71
4	Ferric oxide,FeO_3	0.16
5	Silica SiO_2	0.15
6	Calcium Sulphate $CaSO_4$	0.13
7	Phosphorus oxide, P_2O_5	0.07
8	Loss of Ignition,LOI	23.31

WOOD ASH

Wooden ash is the fine dust that remains after burning wood, whether it be in a fireplace, a campfire, or a commercial power plant. Along with other non-combustible trace elements found in the wood, it is primarily made of calcium compounds. Wooden ash has a large amount of silica in its chemical makeup. The strength, compressibility, and permeability of the wood ash-soil mixture are all controlled by its dry density, which is a crucial factor.

Table-3 Constituents of wood ash

S. No	Chemical Composition	Percentage
1	Calcium oxide, CaO	28.80
2	Magnesium oxide, MgO	5.15
3	Potassium oxide, K_2O	8.55
4	Iron oxide, Fe_2O_3	0.94
5	Sodium oxide,Na_2O	8.50
6	Silica oxide, SiO_2	23.8
7	Aluminium oxide, Al_2O_3	15.62
8	Phosphorus trioxide, P_2O_3	2.23
9	Titanium oxide, TiO_2	0.80
10	Loss of Ignition, LOI	2.60

Figure -1: Black cotton soil, lime & wood ash

1.2 LITERATURE REVIEW

Vishal et al. (2018) Black cotton soils cover a significant amount of central India and a small piece of south India. The basalt and trap rocks that created these soils are residual deposits. The soils here are excellent for

cultivating cotton. High plasticity clays are found in black cotton soils. The soils exhibit significant shrinkage and swelling properties. The soils have a very low bearing capacity and shearing strength. The soil needs to be stabilised, and the strength needs to be high to prevent these situations. RHA is the fibrous rice residue that is left behind after the rice husk is burned to produce ash. According to the chemical analysis of rice ash, silica, potassium, iron, calcium, magnesium, and aluminium were the primary components. when RHA is mixed by mass in percentages of 4%, 8 %, 12 %, and 16 % with black cotton soil. Geotechnical properties are then assessed.

Mishra et al. (2017) Studied results of sea shrimp shells on the factors governing soil strength in clay. He found that the OMC falls off as the sea shell powder content increases, with a 15% sea shell powder content producing a 16.6% OMC. UCS and CBR values increase with the addition of sea shrimp shells, and at the ideal content, they increase by 14 times, or 2.89 times the value of the virgin soil at its beginning. In comparison to the value of virgin soil, the UCS value increased by 14% for every 5% SSP in the soil.

Harish (2017) The subgrade is a crucial part of the pavement's construction. It transfers the entire burden to the ground over a bigger region. The type of subgrade soil and its engineering qualities have an impact on performance and resilience the pavement. Regur soil, sometimes referred to as expansive soil, is one of the troublesome soils that we encounter during construction. Improvements to geomechanical characteristics are crucial in these inevitable circumstances. One approach of ground improvement techniques is stabilisation. In the current investigation, lime has been used to steady black cotton soil. The results have demonstrated the soil's toughness qualities have improved, and its flexibility index has decreased. There has been a noticeable increase in CBR value.

Manjunath et al. (2012) The adjustment or modification of one or more soil properties to enhance a soil's engineering qualities and performance is known as soil stabilisation. Low shear strength and high swell potential are two characteristics of black cotton soil. It is widely recognised to use cement or lime to stabilise such soil. However, only a small number of researchers have explored using the industrial waste known as blast furnace slag for this purpose. This investigation's goal is to ascertain the effects of GGBS on black cotton soil that contains minute levels of lime. By utilising industrial waste and lowering carbon footprint by avoiding cement, it is thought to be particularly beneficial for the intended application as well as for the environment.

Saranjeet et al. (2011) In order to enhance engineering capabilities of regur soils, the study suggests solid waste removal as a practical and affordable solution (B. C. soil). Rice husk and FA were applied to the soil in an effort to promote soil stability RHP. According to IS 2720, tests of UCS and (LL,PL) were conducted. Natural soil is given a 15 % FA and RHP concentration for 28 days, which causes a rise in UCS from 198 Kpa to 253 Kpa. Its results demonstrate that the strength qualities of the soil were not improved by the addition of FA and RH powder at a weight-based rate of 12.5%. However, the results of the 1, 7, 14, 21, and 28 days cured indicate that the RH and FA mixture gradually gains strength with extended curing times.

1.3 OBJECTIVES

The goal of the current study is to ascertain that soil engineering parameters may be improved by using lime and wood ash.

1. To evaluate compaction behaviour of black cotton soil treated by lime and wood ash.

2. To calculate the optimum amount of lime and wood ash for unconfined compressive strength.

3. To calculate optimal amount of lime and wood ash in proportion to the California Bearing Ratio.

1.4 METHODOLOGY

The procedure used in this study is covered in this section Step-by-step studies were conducted with various amounts of additives applied to the soil for all tests, such as Unconfined Compressive Strength, OMC-MDD, and CBR.

- Specific gravity test
- Liquid limit
- Plastic limit
- Plasticity index
- Standard Compaction Test
- Unconfined Compressive Strength (UCS)
- California Bearing Ratio (CBR)

1.5 MIX PROPORTIONS USED

The purpose of mixture design on finding absolute amount of lime and wood ash to stabilise the black cotton soil and achieve desired strength requirements. To succeed may be desired. Different ratios of soil, lime, and wood ash were mixed together to conduct various tests.

Table-4 Mix proportion (soil% + lime%)

SAMPLES	SOIL (%)	LIME(%)	TOTAL(%)
1	100	0	100
2	98	2	100
3	96	4	100
4	94	6	100
5	92	8	100

The strength parameters will be calculated using the optimised lime sample in a fixed proportion, and the behaviour of the black cotton soil will also be examined with various amounts of wood ash (WA).As per the previous studies done on regur soil for various mixtures the percentage for different ingredients was taken into the optimum percentage which I have taken above and the results were satisfactory that's why I took the Lime percentage of 2%,4%,6%,& 8%.

Table-5 Mix proportion (soil & optimum lime% + WA%)

SAMPLES	SOIL + OPTIMUM LIME CONTENT (%)	WA(%)	TOTAL(%)
1	92	8	100
2	84	16	100
3	76	24	100

As per the previous studies done on regur soil with different mixtures the percentage for different mixture ingredients were taken into the optimum percentage which I have taken above and the results were satisfactory that's why I took the mixture percentage of Lime and wood ash of 8%,16%,& 24%.

2. RESULTS & DISCUSSION

Test results are summarized in given below tables and charts. Black Cotton Soil has been mixed with different proportion of lime 0%,2%, 4%,6% and 8% as shown in table 6 to 8 and figure 2 to 4. The OMC increases where as MDD decreases at 6% lime content it increases and at 8% it decreases. In UCS the black cotton soil mixed with lime in different proportions the UCS increases maximum at 6% lime content after it decreases and in CBR the black cotton soil mixed with lime increases at 6% and at 8% lime content it decreases. Thus the optimum quantity of lime is 6% for maximum effect on OMC-MDD,UCS and CBR. The black cotton soil mixed with lime gradually increases maximum at 6% and at 8% lime content it starts to decrease.

TABLE-6 OMC and MDD with different percentages of Lime

Sr. No	PERCENTAGE OF LIME	DRY DENSITY (kN/m³)	OPTIMUM MOISTURE CONTENT (%)
1	0	18.53	14
2	2	18.48	14.3
3	4	18.34	14.9
4	6	18.30	16.2
5	8	18.27	16.6

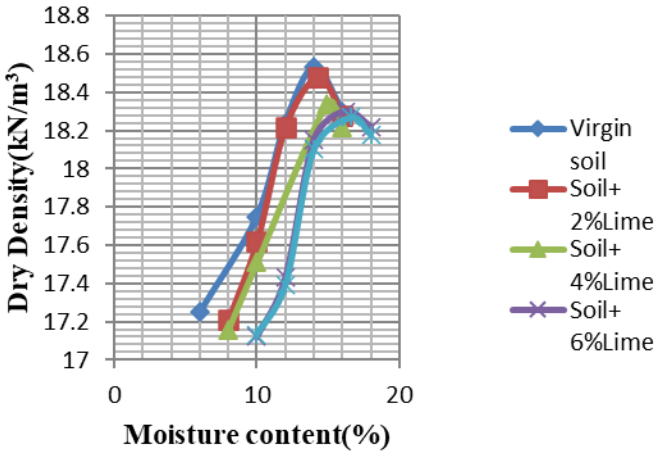

Chart-1. OMC vs MDD of soil with different percentages of lime

TABLE- 7 Results of the UCS test with various Lime percentage change are stated in table below:

Sr. No	Percentage of Lime	UCS (kN/m²)
1	0	191.7
2	2	284.6
3	4	348.5
4	6	414.9
5	8	294.6

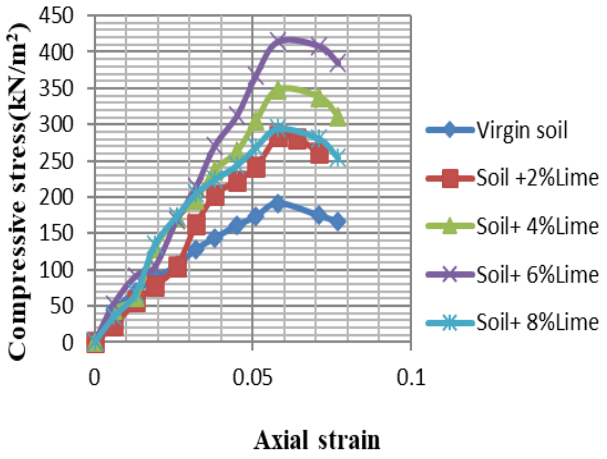

Chart -2. Axial strain vs Compressive stress of soil with different percentages lime

TABLE-8 Results of the CBR test with various Lime percentage change are stated in table below:

Sr. No	PERCENTAGE OF LIME	CBR (%)
1	0	2.79
2	2	6.95
3	4	8.85
4	6	10.24
5	8	9.79

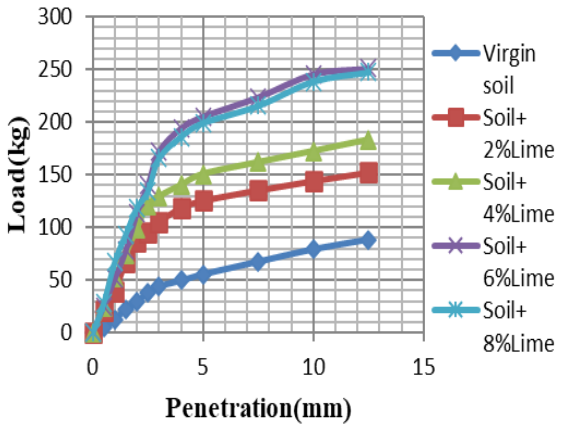

Chart-3. Load vs Penetration of soil with different percentages of lime

2.1 RESULT OF MIX PROPORTION OF WOOD ASH AND LIME:

Test results of black cotton soil with mix proportion of wood ash and lime at different percentage are 8%,16% and 24% mixed with 6% optimum lime are summarized in given below tables from 9 to 11 and charts from 1 to 6. The OMC increases where as MDD decreases , at 16% wood ash content with 6% lime it increases and at 24% it decreases. In UCS the black cotton soil mixed with wood ash at 6% optimum lime the UCS increases maximum at 16% wood ash and after it decreases .In CBR the black cotton soil mixed with 16% wood ash with 6% optimum lime it increases at 16% and at 24% it decreases.

Table-9 OMC and MDD after adding wood ash in percentages of 8%,16%and 24% with optimized lime i.e. 6% is represented below

Sr. No	PERCENTAGE OF WOOD ASH	DRY DENSITY (kN/m³)	OPTIMUM MOISTURE CONTENT (%)
1	8	18.21	16
2	16	17.95	18.9
3	24	17.88	20.5

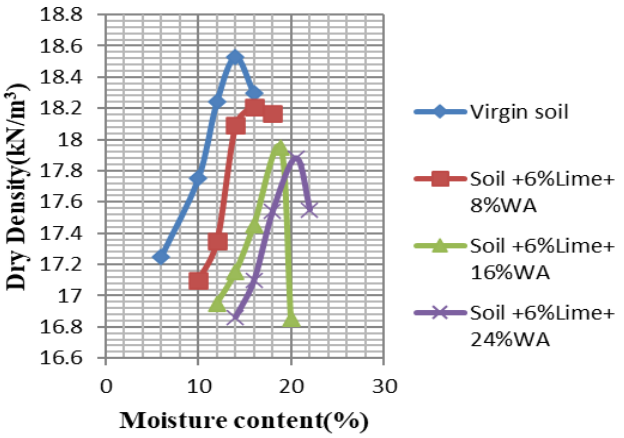

Chart-4. OMC vs MDD of soil mixed with lime and wood ash at different percentages

Table-10. UCS values with different percentage of wood ash

Sr. No	Percentage of wood ash	UCS (kN/m²)
1	8	3.951
2	16	5.145
3	24	4.149

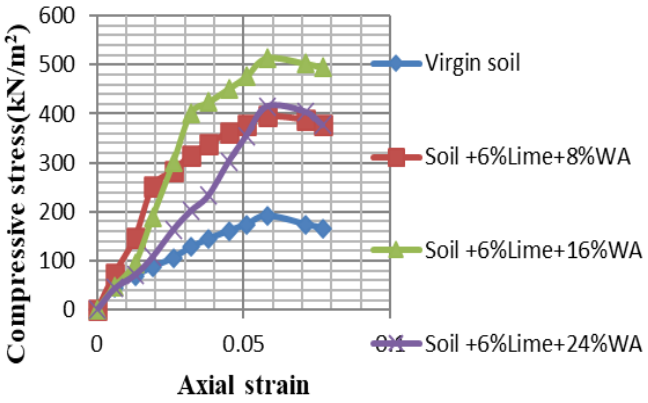

Chart-5. Axial strain vs Compressive stress of soil mixed with lime and wood ash at different percentages

Table-11. CBR values with different percentages of wood ash

Sr. No	PERCENTAGE OF WOOD ASH	CBR (%)
1	8	16.09
2	16	19.39
3	24	18.25

3. CONCLUSIONS

- It was observed that OMC increased by 15.71 % with an increase in the amount of lime in BCS (Soil: lime =94:6:0), whereas MDD tends to decrease by 1.25 %. According to the study, the MDD marginally decreased and the OMC slightly increased when both of the additives, lime and wood ash, were used in BCS at various ratios. It was determined that when lime and wood ash were added to soil in different concentrations, MDD was slightly lowered by 1.94 % (soil: lime:WA =84:16:6) and OMC was slightly raised by 16.66 %.

- The percentage of rise in estimation of UCS when tests were done with 2 %, 4 %, 6 %, and 8% lime was found to be 48.46 %, 81.79 %, 116.43 %, and 53.67 %, respectively, compared to the virgin soil.The increment in UCS is greatest at 6% lime is 116.43%.The experiment on the combined example of lime (6%) and wood ash (16%) reveals the highest estimate of UCS, which is found 514.5 kN/m². When contrast with virgin soil, the increment is 168.38 %.

- The value of California Bearing Ratio of the virgin black cotton soil is 2.79%.The California Bearing Ratio (CBR) value of the soil modified with 6% lime is 10.24 %; this is a 266.92 % improvement over virgin soil. The combined soil sample containing 6 % lime and 16 % wooden ash was found to have a soaked CBR value of 19.39 percent, which is an increment of 594.50 % to virgin soil.

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BIOGRAPHIES

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