Black Cotton Soil Stabilization using Plastic Fibers, Rice Husk Ash and $CaCl_2$

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Abstract - *Expansive soils are a worldwide problem that poses several challenges for civil Engineers due to its poor bearing capacity, low shear strength, etc. The aim of this project is to stabilize the black cotton soil using RHA and CaCl² and reinforcing by using Plastic fiber. This would improve the soil properties effectively and are economical.*
The tests conducted for Physical Properties are Moisture Content, Grain Size Distribution and for Engineering Properties are Standard Proctor Compaction Test, California Bearing Ratio Test, Atterberg's Limit test, Free Swell Index Test and Unconfined Compressive Strength Test are done for black cotton soil mixed with different proportions of Rice Husk Ash and Plastic Fibers then the results are tabulated.

***Key Words*: CBR Test, Black Cotton Soil, Plastic Fibres, Rice Husk Ash, $CaCl_2$**

1. INTRODUCTION

Generally from the studies we know that black cotton soil is found to contain montmorillonite clay mineral which has high expansive characteristics. As the colloidal clay content in BC soil is up to 50%. It is also found that it has high plastic limit, high liquid limit and low shrinkage limit. The compaction characteristic of such soil is that they have low dry density and high OMC. The black cotton soil UCC and CBR values are also low for this soil.
Solution to this problem is soil stabilization is done by the processes of blending and mixing materials with the soil to improve their certain properties and to achieve a desired size particles or the mixing of normally available admixture that may alter the gradation or plasticity may act as an binder for the cementation of the soil. This might result in reduce the permeability & compressibility on properties of expansive soils and hence increases its bearing capacity.

1.1 Importance of Soil Stabilization

The Stabilized soils gives us an stronger working platform for the foundation for all other work of projects. After stabilization process, weaken soil gets more strength in it. Which means that soil is not weak anymore and has significantly reduced permeability resulting in reduced shrinkage/swelling potential. In addition, soils that have been stabilized have also under goes some modification.
We can say that the soil has been physically changed making it easier for compaction and reducing it's plasticity. Easier compaction is equal to achieving maximum dry density easier.

1.2 Merits and De-Merits of Soil Stabilization

Merits of Soil Stabilization

1. Stabilizing soils with binders is now an extremely cost effective method of converting poor quality soil into a strong impermeable medium.
2. There is no need to bring other type of soil when the soil on site can be used after a simple treatment process.
3. Improved to give the properties required for construction.
4. Soil stabilization is an different method for improving the characteristics and performance of the soil.

De-Merits of Soil Stabilization

1. Requires a lot of products per application.
2. Requires extensive soil testing before application.
3. Not always environmentally friendly.
4. Time consuming.

2. METHDOLOGY

Following tests which we are going to be performed on the Black Cotton soil are according to all IS Standards. All the apparatus used during the tests are confirmed from the IS Codes. Further results for the tests are given from the IS Standards limits.

After reviewing different Authors papers first, we have to collect the materials that are required for conducting the project. After collecting the materials, we will determine the standard soil properties to determine its Class. Our next step is to find the optimum combination for soil stabilization with Rice Husk Ash and $CaCl_2$.

After finding the optimum combination the further step is to determine the soil reinforcement (Plastic Fiber) combination.

Materials used During the Testing

1. Subgrade Soil (Black Cotton Soil).
2. Rice Husk Ash (RHA).
3. Calcium Chloride ($CaCl_2$).
4. Plastic Fiber.

Fig-1 Black Cotton Soil

Fig-2 Rice Husk Ash

Fig-3 Calcium Chloride

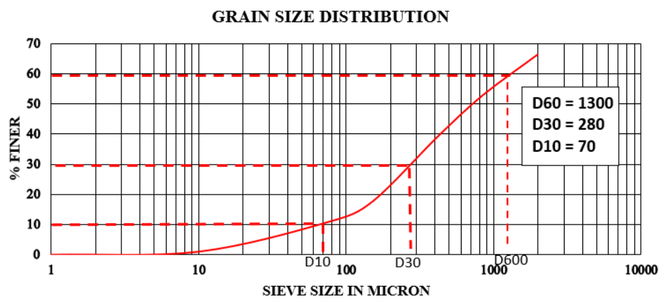
Fig-4 Plastic Fiber

Table-1 Experimental Programme.

Soil Combination	Tests Conducted
Soil alone	Grain size distribution
Soil + RHA	Specific gravity
Soil + $CaCl_2$	Atterberg limits
Soil + RHA + $CaCl_2$	Compaction test
Soil + RHA + $CaCl_2$ + Plastic Fiber	CBR test
	Free swell index

3. BLACK COTTON SOIL OBSERVATIONS

3.1 Grain Size Distribution



Graph-1: Grain size distribution graph

The value of coefficient of curvature, C_c obtained for Black Cotton Soil is 18.57 and that of coefficient of uniformity, C_u is obtained as 0.86. For the graded soil the standard value of C_c lies between 1 and 3 and for fine soil the C_u value should be greater than 6. Since both of these criteria are not met, the soil is classified as poorly graded.

3.2 Specific Gravity

Table-2: Specific gravity

SAMPLE	1	2	3
SPECIFIC GRAVITY	2.32	2.31	2.33

The specific gravity of Black Cotton Soil has been obtained as 2.32. The specific gravity of soil normally has a range of 2 - 2.8 and hence the Black Cotton Soil is within the specified range.

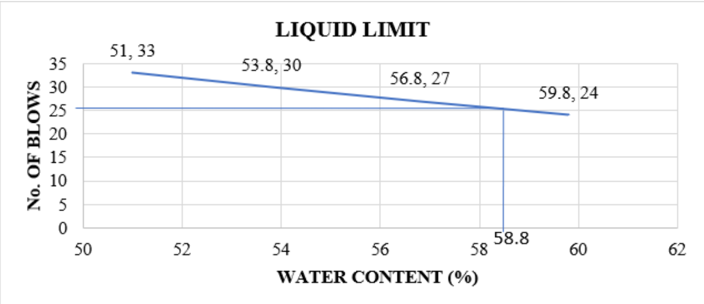
3.3 Atterberg's Limit

a. **Shrinkage limit**-From the experiment the shrinkage limit of soil has been obtained as 12.12% and shrinkage ratio is obtained as 1.89. This shows that the shrinkage limit of the soil is low.

b. **Liquid limit:**

Table-3: Liquid limit

WATER CONTENT	51	53.8	56.8	59.8
NO. OF BLOWS	33	30	27	24



Graph-2: Liquid Limit Graph

The liquid limit of the soil is obtained from the graph corresponding to 25 blows as 58.8%. Hence the liquid limit of the soils high.

c. **Plastic limit**

Table-4: Plastic Limit

SAMPLE	1	2	3
PLASTIC LIMIT	23.08	28.57	37.5

The average plastic limit of soil is obtained as 29.72%. Hence the soil is highly plastic.

d. **Liquidity index**

Liquidity index of the soil is obtained as -0.27. Since the liquidity index is less than zero the soil is in semi-solid state and is stiff.

e. **Consistency index**

The consistency index of the soil is obtained as 1.27. Since the liquidity index is greater than one the soil is in semi-solid state and is stiff.

f. **Shrinkage index**

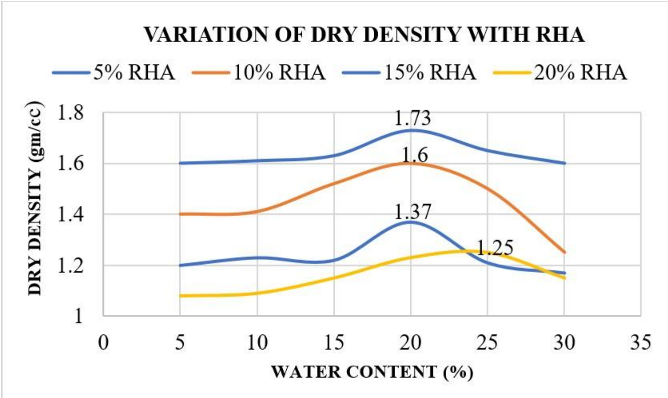
The shrinkage index of soil is obtained as 17.6%.

g. **Plasticity index**

The plasticity index of the soil is obtained as 29.08% and the A- line is obtained as 28.324%. As per the plasticity chart we obtained that the soil is above A-line and hence belongs to CH group. Thus, soil is highly clay or high plasticity.

4. OPTIMISATION FOR SOIL STABILISATION

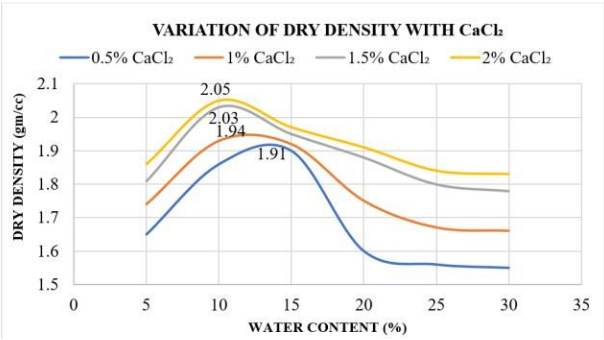
4.1 Effect of RHA (Rice Husk Ash) on Black Cotton Soil



Graph-3: Effect of RHA on Black Cotton Soil

Compaction of soil with RHA showed a decrease in dry density with increasing OMC

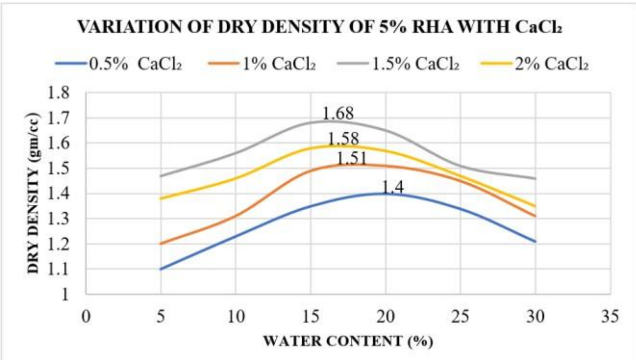
4.2 Effect of $CaCl_2$ (Calcium Chloride) on Black Cotton Soil



Graph-4: Effect of $CaCl_2$ on Black Cotton Soil

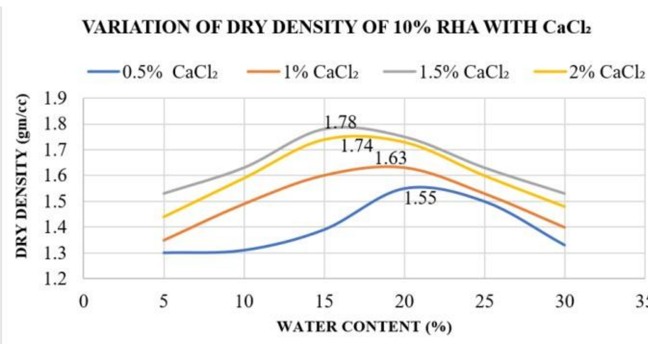
Compaction of soil with $CaCl_2$ showed an increase in dry density with decreasing OMC

4.3 Effect of $CaCl_2$ and 5% RHA on Black Cotton Soil



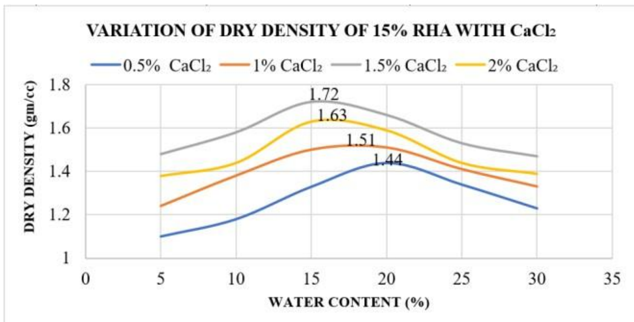
Graph-5: Effect of $CaCl_2$ and 5% RHA on Black Cotton Soil

4.4 Effect of $CaCl_2$ and 10% RHA on Black Cotton Soil



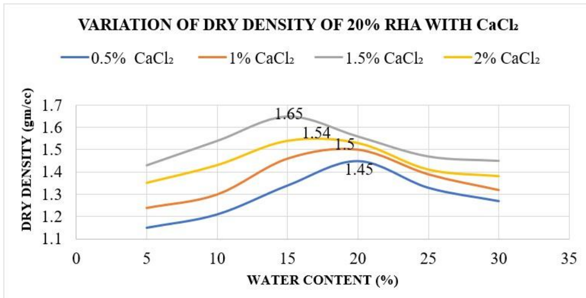
Graph-6: Effect of $CaCl_2$ and 10% RHA on Black Cotton Soil

4.5 Effect of $CaCl_2$ and 15%RHA on Black Cotton Soil



Graph-7: Effect of $CaCl_2$ and 15% RHA on Black Cotton Soil

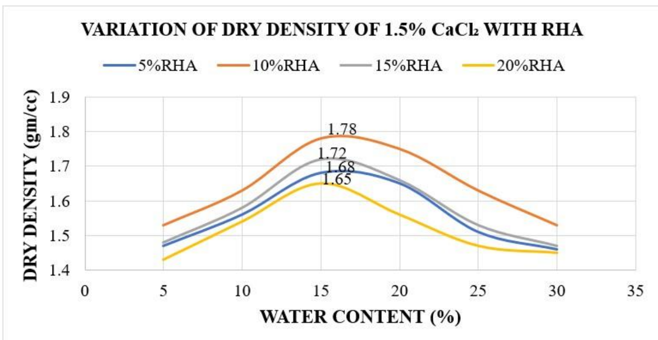
4.6 Effect of CaCl2 and 20%RHA on Black Cotton Soil



Graph-8: Effect of CaCl2 and 20%RHA on Black Cotton Soil

The optimum combination is taken as 20% RHA with 1.5% $CaCl_2$ which has maximum dry density with minimum water content.

4.7 Effect of RHA and 1.5%$CaCl_2$ on Black Cotton Soil

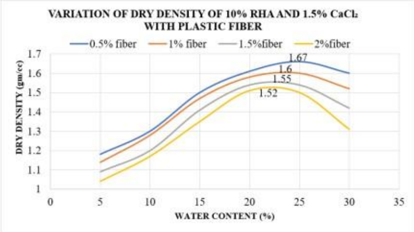


Graph-9: Effect of RHA and 1.5% CaCl2 on Black Cotton Soil

The optimum combination is taken as 10% RHA with 1.5% CaCl2 which has maximum dry density with minimum water content.

4.8 OPTIMISATION FOR SOIL REINFORCEMENT

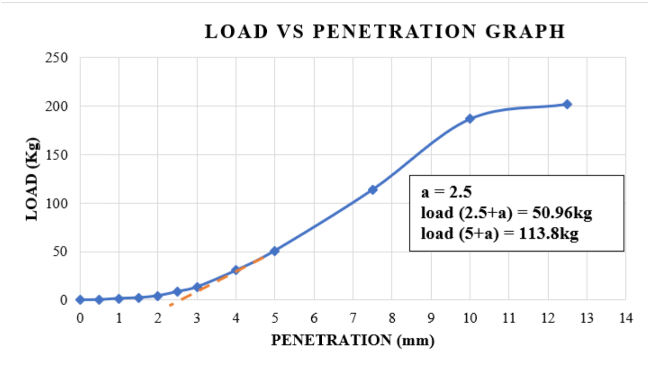
Effect of Plastic Fiber, 10%RHA and 1.5%$CaCl_2$ on Black Cotton Soil



Graph-10: Effect of Plastic Fiber, 10%RHA and 1.5%CaCl2 on Black Cotton Soil

5. ANALYSIS FOR SOIL STABILISED SOIL PROPERTY

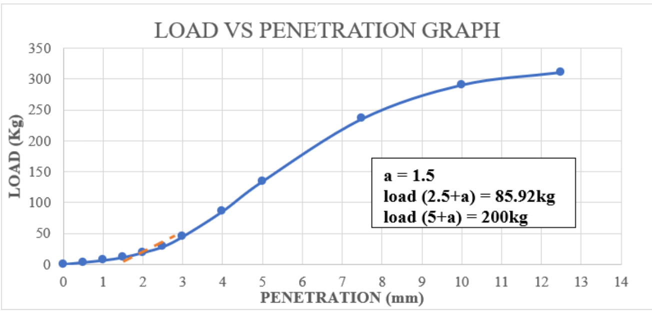
5.1 California Bearing Ratio test with10% RHA and 1.5% $CaCl_2$ stabilized soil



Graph-11: CBR of stabilized soil with10% RHA and 1.5% $CaCl_2$Stabilized soil

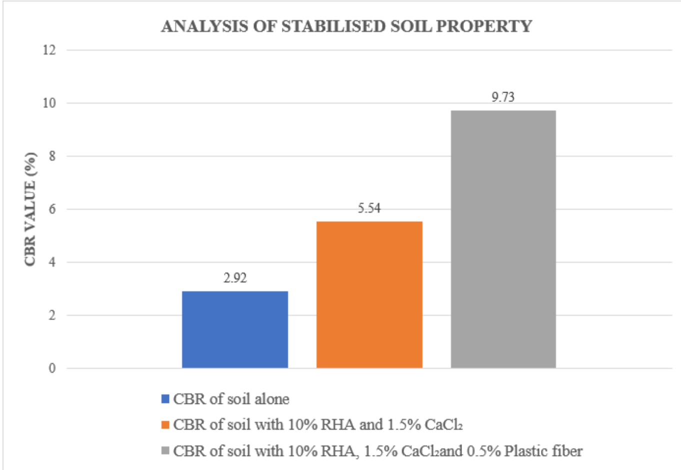
CBR value with10% RHA and 1.5% $CaCl_2$ stabilized soil is obtained as 5.54%.

5.2 California Bearing Ratio test with10% RHA, 1.5% $CaCl_2$and 0.5% Plastic Fiber stabilized soil



Graph-12: CBR test with10% RHA, 1.5% $CaCl_2$and0.5%Plastic fiber stabilized soil

CBR value with10% RHA, 1.5% CaCl2 and 0.5% Plastic Fiber stabilized soil is obtained as 9.73%.



Graph-13: Analysis of stabilized soil property

6. CONCLUSION

- RHA and $CaCl_2$ can't be used alone for stabilizing process as they lack cementing agent for increased strength and are difficult to pulverized soil at low water content respectively. Thus, optimization of above 2 combinations can be an effective method for soil stabilization and it is found at 10% RHA and 1.5% $CaCl_2$.
- Reinforcing the soil with Plastic Fibber can improve the strength characteristics of the soil and the optimum performing subgrade is obtained with the application of 10% RHA, 1.5% $CaCl_2$ and 0.5% Plastic Fibber.
- The CBR value of Black Cotton Soil increased after addition of 10%RHA + 1.5% $CaCl_2$ (5.54%) and 10%RHA + 1.5% $CaCl_2$ + 0.5% Plastic Fiber (9.73%) as compared to untreated soil (2.92%). Good CBR value increases the stability of soil.

7. REFERENCES

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