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EXPERIMENTAL INVESTIGATION OF SOIL STABILISATION USING CHEMICALS AND PALM FIBER

Kannan L

Assistant Professor, Department of Civil Engineering, TRP Engineering College, Trichy,Tamil Nadu, India

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Abstract – Soil is the major base for any type of structure; it mainly consists of minerals, organic matter, liquids etc. It represents the stability of any type of soil which the structure retains itself without affecting its properties. Black cotton soil is one among the type of expansive soil. Its property is of swelling excessively when wet and shrinks highly when exposed to dry condition. In black soil it mainly consists of montmorillonite mineral which has the ability to undergo large swelling and shrinkage. To overcome this, properties of soil should be enhanced by artificial means known as 'Soil Stabilization'. The main additives used in this are sodium chloride, magnesium chloride, calcium chloride and palm fiber. the effect of adding different chloride compounds including (NaCl, $MgCl_2$, $CaCl_2$) on the engineering properties of silty clay soil. Various amounts of salts (2%, 4%, and 8%) were added to the soil to study the effect of salts on the compaction characteristics, consistency limits and compressive strength. The main findings of this study were that the increase in the percentage of each of the chloride compounds increased the maximum dry density and decrease the optimum moisture content. Natural fibers are used widely in soil reinforcement procedure all around the world during many centuries and one of the most durable and applicable of these materials is the palm fiber. These studies have considered the application of the palm fibers` effects on the behavior of the black cotton soil. The results show that this kind of randomly distributed reinforcement would significantly affect and alter the characteristics of the reinforced soil, but not always by improving them.

Key Words*: Soil Stabilization, Black Cotton Soil, Maximum Dry Density, Optimum Moisture Content, Nacl, $Mgcl_2$, $Cacl_2$, Palm Fiber, Unconfined Compressive Test.

1. INTRODUCTION

In India about 51.8 million hectares of the land area are covered with Expansive soils (black cotton soil).The Black cotton soils are very hard when dry, but lose its strength completely when in wet condition. Expansive soils are a worldwide problem that poses several challenges for civil Engineers. Various methods are adapted to improve the engineering characteristics of expansive soils. The problematic soils are either removed and replaced by good and better quality material or treated using additive. The stabilization of the problematic soils is very important for many of the geotechnical engineering applications such as pavement structures, roadways, building foundations, channel and reservoir linings, irrigation systems, water lines, and sewer lines to avoid damage due to settle of soft soil or to the swelling action of expansive soil.

It shows major volume changes due to change in the moisture content. When the soil is dry they are shrink the large crack is to be form. This soil contains minerals such as montmorillnite that are capable of absorbing water. One may achieve stabilization by mechanically mixing the natural soil and stabilizing material together so as to achieve a homogeneous mixture or by adding stabilizing material to an undisturbed soil deposit and obtaining interaction by letting Stabilization of black cotton soil using Chloride Compounds it permeate through soil voids . Where the soil and stabilizing agent are blended and worked together, the placement process usually includes compaction. Soil stabilizing additives are used to improve the properties of less–desirable rood soils. When used these stabilizing agents can improve and maintain soil moisture content, increase soil particle cohesion and serve as cementing and water proofing agents. Although mechanical compaction, dewatering and earth reinforcement have been found to improve the strength of the soils, other method like stabilization using fibers are more advantageous. Soil stabilization using natural fiber such as palm fiber is an alternative method for the improvement of sub grade soil of pavement. It can significantly enhance the properties of the soil used in the construction of road infrastructure.

1.1Soil Stabilization

The term soil stabilization means the improvement of stability or bearing power of the soil by the use of controlled compaction, proportioning and/or the addition of suitable admixture or stabilizers. Soils are generally stabilized to increase their strength and durability or to prevent erosion and dust formation in soils. The main aim is the creation of a soil material or system that will hold under the design use conditions and for the designed life of the engineering project. 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. MATERIALS

This section deals with the various materials used in the study including the Natural Black soil and Agricultural waste products. The materials have been dealt with individually along with their properties.

2.1 Natural Black Soil

The Soil sample was taken from siruganur is a neighborhood of the city of Tiruchirappalli in Tamil Nadu, India. It comes under the city limit with Tiruchirappalli City Corporation and Tiruchirappalli north Taluk. In this area where availability of black soil is more and rich in mineral content.

Figure 1: Natural Black Soil

2.2 Sodium Chloride

Salt is currently mass produced by evaporation of seawater or brine from brine wells and salt lakes. Mining of rock salt is also a major source. Sodium chloride is also known as salt or halite is an ionic compound with the chemical formula Nacl, representing a 1:1 ratio of sodium and chloride ions. Sodium chloride is the salt most responsible for the salinity of seawater and of the extra cellular fluid of many multi cellular organisms. In the form of edible or table salt it is commonly used as a condiment and food preservative. A major consumer of sodium chloride is deicing of roadways in sub-freezing weather. Salt is added to secure the soil and to provide firmness to the foundation on which highways are built. The salt acts to minimize the effects of shifting caused in the subsurface by changes in humidity and traffic load.

Figure 2: Sodiumchloride

2.3 Magnesium chloride

Magnesium chloride is the name for the chemical compound with the formula $MgCl_2$ and its various hydrates $MgCl_2(H_2O)_2$. These salts are typical ionic halides, being highly soluble in water. The hydrated magnesium chloride can be extracted from brine or sea water. In North America, magnesium chloride is produced primarily from Great Salt Lake brine. It is extracted in a similar process from the Dead Sea in the Jordan valley. Magnesium chloride, as the natural mineral bischofite, is also extracted (via solution mining) out of ancient sea beds. Anhydrous magnesium chloride is the principal precursor to magnesium metal, which is produced on a large scale. Hydrated magnesium chloride is the form most readily available. Magnesium chloride is most commonly used for dust control and road stabilization. Its second-most common use is ice control.

Figure 3: Magnesium Chloride

2.4 Calcium chloride

Calcium chloride is the ionic compound of calcium and chlorine. It is a salt that behaves as a typical ionic halide, being solid at room temperature and highly soluble in water. Common applications include brine for refrigeration plants, ice and dust control on roads, and desiccation. Because of its hygroscopic nature, attracting and holding water, anhydrous calcium chloride must be kept in airtight containers. Calcium chloride can serve as a source of calcium ions in an aqueous solution, as calcium chloride is soluble in water. This property can be useful for displacing ions from solution. Calcium chloride can be produced directly from limestone, but large amounts are also produced as a by-product of the Solvay process. By depressing the freezing point of water, calcium chloride is used to prevent ice formation and to deice. This is particularly useful on road surfaces.

Figure 4: Calcium chloride

2.5 Palm Fiber

Palm fiber is the natural fibers which are obtained from the wastes of palm skin which is called “Sisi” by the natives in Karman’s area and also have acceptable mechanical properties and durability in natural conditions. Thus in recent years the application of this area like strength and ductility randomly distributed palm fibers silty sand soils and some graduation thesis have been also performed on such cases. Reinforcing fibers were gained by cutting the palm waste skin. Natural fibers have been used to reduce shrinkage cracks in clayey soils without the least environmental nuisances and at almost low performance costs.

Figure 5: palm fiber

3. SAMPLE PREPARATION

Soil sample as received from the field is dried in the air or in sun. The clods are broken with a wooden mallet to hasten drying. The organic matter, like tree roots and pieces of bark were removed from the sample. Then the sample is kept in oven for drying at 110°C temperature for 24hrs. For the tests like liquid limit, plastic limit, light compaction the sample was air dried. Using the sample the basic laboratory tests are conducted as specified. Three types of chloride compounds were used, namely, NaCl, MgCl2, and CaCl2. Each one of these salts was dissolved in water and then mixed with soil.Then the chemicals mixed soil is also kept in oven for maintaining the dry form of the soil. For different blend mixes the chemical content was taken according to certain percentages by weight of soil and it is mixed with soil in dry form itself. The palm fibers were cut into the length of 30mm and the thickness of 0.35 mm. Four different values of fibers weight ratio were utilized in production of samples to clarify the results that the changes would turn out. Some amounts palm fibers were appended to the soil mixture with different values of 0%,0.25%,0.5%,1% of the dry soil weight Adequate numbers of sample were produced by compaction of the soil an randomly distributed fibers mixture with the optimum compaction moisture content of 15 percents. Then, the samples sides were isolated to prevent the collapse of the cylinders as they are submerged under the water .samples were set on a fixed porous stone to be able to absorb the water from both top and bottom sides All the materials are taken in dry form and mixed mechanically, then the test procedure is conducted.

4. EXPERIMENTAL TEST VALUES & RESULTS

This chapter covers the results of the various experimental studies. The results that are presented include admixture percentages and the various testing results for the soil and additive combinations.

4.1 Effect of additives on soil properties

This section deals with the effect of stabilizers and additives on the various properties of the soil. The properties that have been analyzed for interpretation are Liquid limit, Plastic limit and unconfined compressive strength.

4.2Effect on Liquid Limit, Plastic Limit & Plasticity Index

The variation of liquid limit, plastic limit, and plasticity index with the additives of chemicals has been determined.

Table 1.variation of liquid limit, plastic limit and plasticity index with addition of Nacl at 0%, 2%, 4%, 8%

TEST EXPERIMEMT	BLACK SOIL + Nacl			
	0%	2%	4%	8%
LIQIUD LIMIT	42%	39%	37%	34%
PLASTIC LIMIT	33.33%	30.43%	26.99%	22.45%
PLASTICITY INDEX	8.67%	8.57%	10.01%	11.55%

Table 2.variation of liquid limit, plastic limit and plasticity index with addition of $Cacl_2$ at 0%, 2%, 4%, 8%

TEST EXPERIMEMT	BLACK SOIL + $Cacl_2$			
	0%	2%	4%	8%
LIQIUD LIMIT	42%	38%	36%	32%
PLASTIC LIMIT	33.33%	29.63%	25%	21.95%
PLASTICITY INDEX	8.67%	8.37%	11.0%	10.05%

Table 3.variation of liquid limit, plastic limit and plasticity index with addition of Mgcl2 at 0%, 2%, 4%, 8%

TEST EXPERIMEMT	BLACK SOIL + $Mgcl_2$			
	0%	2%	4%	8%
LIQIUD LIMIT	42%	40%	35%	32%
PLASTIC LIMIT	33.33%	29.63%	25%	21.95%
PLASTICITY INDEX	8.67%	8.42%	7.34%	12%

4.3 Effect on maximum dry density:

The variation in maximum dry density with additives is diagrammatically represented.

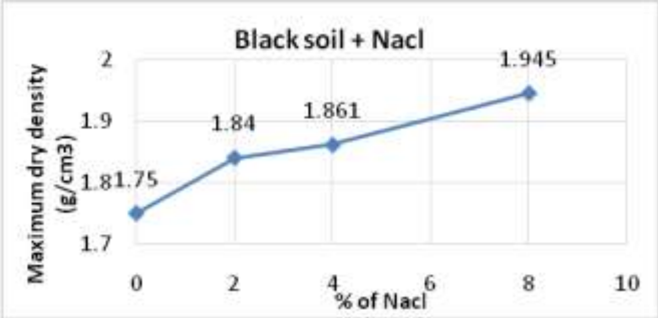

Figure 6: Variation of Maximum dry density with addition of Nacl at 0%, 2%, 4% and 8%

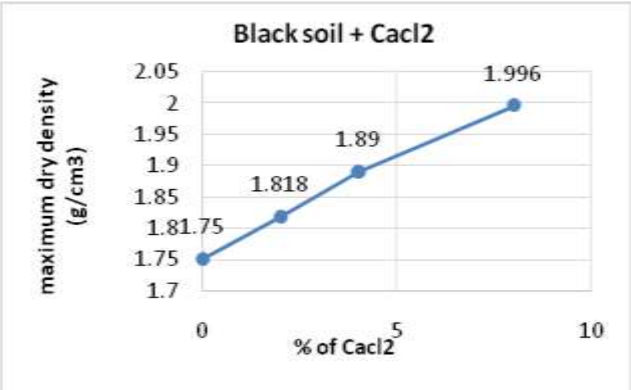

Figure 7: Variation of Maximum dry density with addition of $Cacl_2$ at 0%, 2%, 4% and 8%

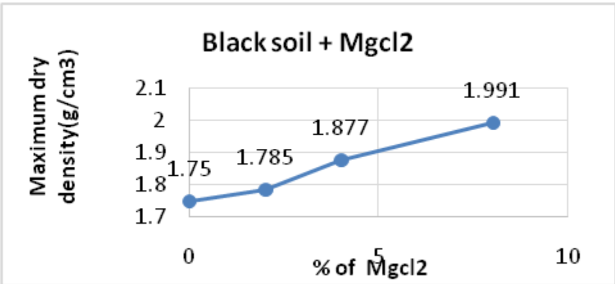

Figure 8: Variation of Maximum dry density with addition of $Mgcl_2$ at 0%, 2%, 4% and 8%

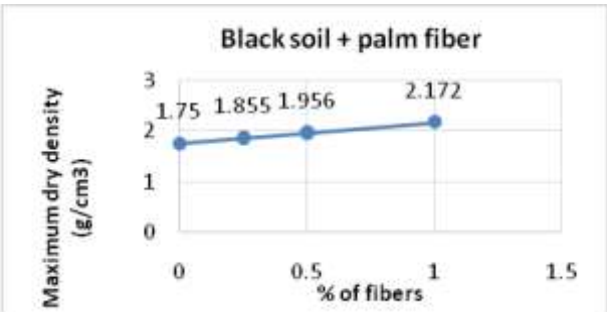

Figure 9: Variation of Maximum dry density with addition of Palm fiber at 0%, 0.25%, 0.5% and 1%

4.4 Optimum Moisture Content Graphical Results:

The variation in optimum moisture content with additives is diagrammatically represented in figure

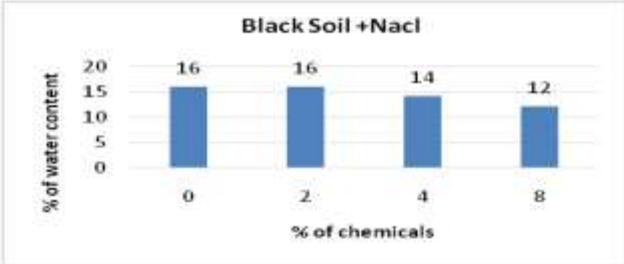

Figure 10: Variation of OMC with addition of Naclat 0% , 2%,4% and 8%

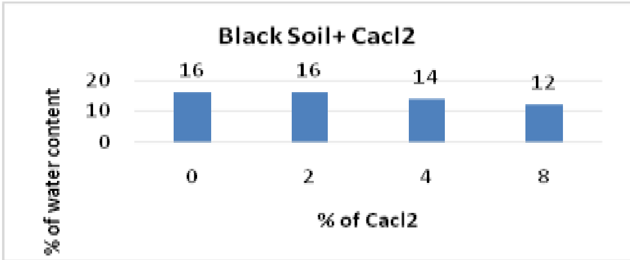

Figure 11: Variation of OMC with addition of $Cacl_2$ at 0% , 2%,4% and 8%

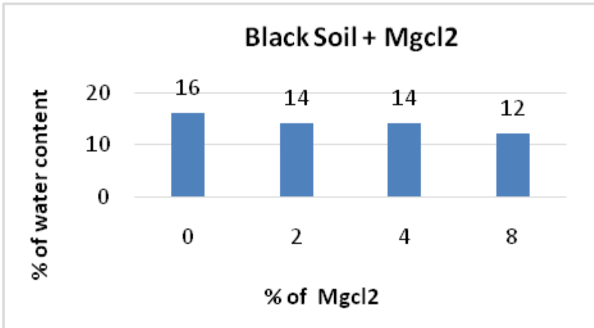

Figure12: Variation of OMC with addition of $Mgcl_2$ at 0%, 2%, 4% and 8%

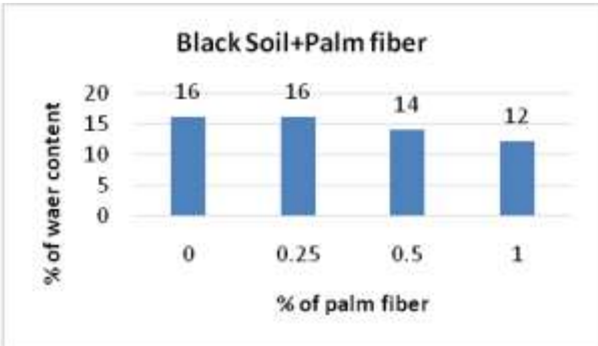

Figure 13: Variation of OMC with addition of palm fiber at 0%, 0.25%, 0.5 % and 1%

4.5 UCC graphical results:

The variation of unconfined compressive test with the additives of chemicals and palm has been determined. This section also represents the graphical results.

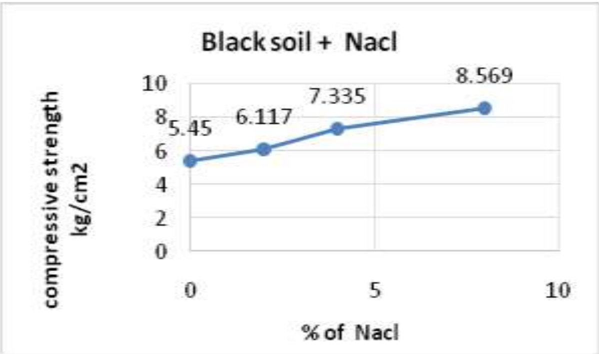

Figure 14: Variation of compressive strength with addition of Nacl at 0% ,2% ,4% and 8%

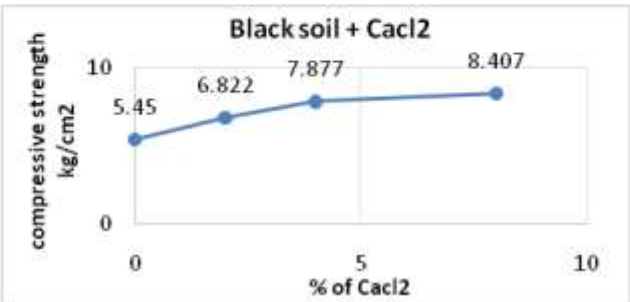

Figure 15: Variation of compressive strength with addition of $Cacl_2$ at 0%, 2%, 4% and 8%

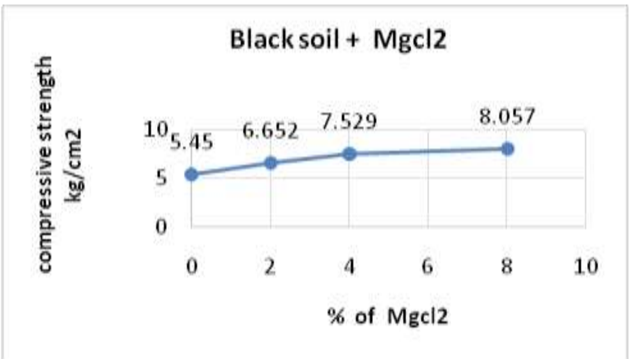

Figure 16: Variation of compressive strength with addition of $Mgcl_2$ at 0%, 2%, 4% and 8%

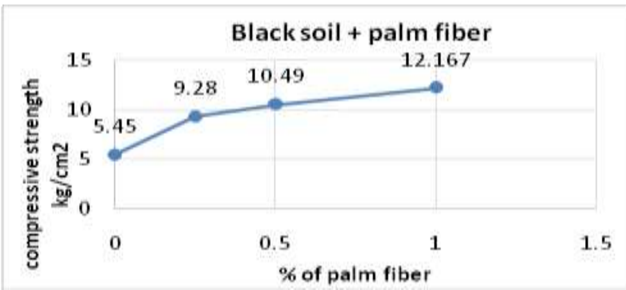

Figure 17: Variation of compressive strength with addition of palm fiber at 0%, 0.25%, 0.5% and 1%.

5. COMPARATIVE GRAPHICAL RESULTS:

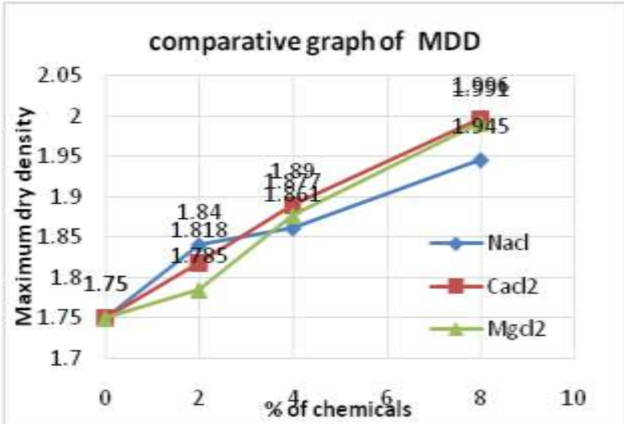

Figure 18: Combined Result of maximum Dry Density with

all additives at 0%, 2%, and 4% and8%

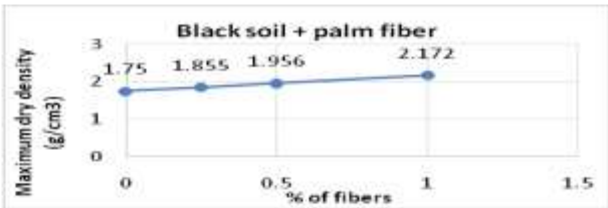

Figure 19: Result of maximum Dry Density with palm fiber at 0%, 2%, 4% and 8%

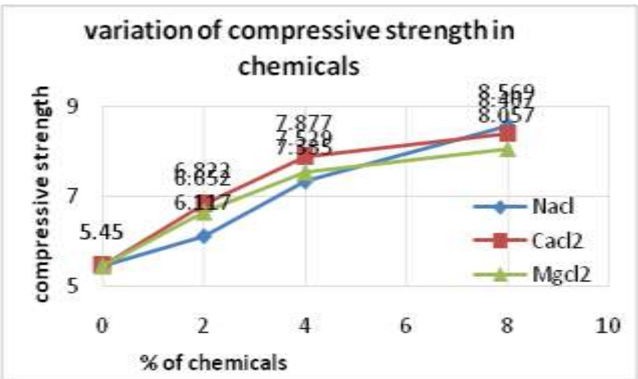

Figure 20: Combined Result of compressive strength with all additives at 0%,2%,4% and 8%

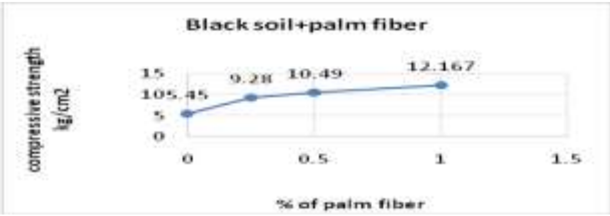

Figure 21: Result of compressive strength with palm fiber at 0%, 0.25%, 0.5% and 1%

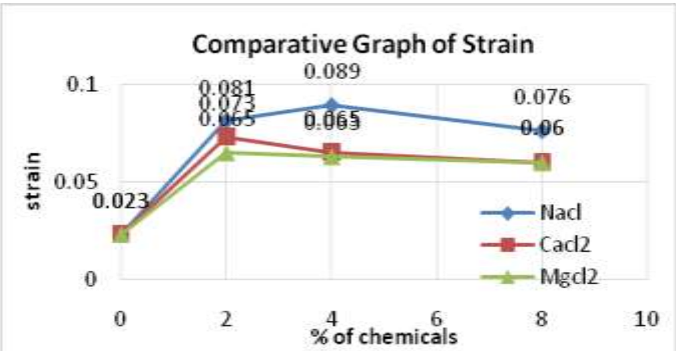

Figure 22: Combined Result of strain with all additives at 0%, 2%, 4% and 8%

Figure 23: Result of strain with palm fiber at 0%, 0.25%, 0.5% and 1%

6. SUMMARY AND RESULTS DISCUSSION

The summary of the results obtained for various experiments are been listed in below tables:

Table 4 Summary of results for Nacl

TEST EXPERIMENT	BLACK SOIL + Nacl			
Addition of chemicals	0%	2%	4%	8%
Maximum dry density(g/cm³)	1.750	1.840	1.861	1.945
Optimum moisture content	16%	16%	14%	12%
Compressive strength(kg/cm²)	54.50	61.17	73.35	80.57
Strain	0.023	0.081	0.089	0.076

The above table shows the summary for sample black soil with addition of Nacl.

Table 5 Summary of results for $Cacl_2$

TEST EXPERIMENT	BLACK SOIL + $Cacl_2$			
Addition of chemicals	0%	2%	4%	8%
Maximum dry density(g/cm³)	1.750	1.818	1.890	1.996
Optimum moisture content	16	16	14	12
Compressive strength(kg/cm²)	5.450	6.822	7.877	8.407
Strain	0.023	0.073	0.065	0.060

The above table shows the summary for sample black soil with addition of $Cacl_2$.

Table 6 Summary of results for $Mgcl_2$

TEST EXPERIMEMT	BLACK SOIL + $Mgcl_2$			
Addition of chemicals	0%	2%	4%	8%
Maximum dry density(g/cm³)	1.750	1.785	1.877	1.991
Optimum moisture content	16%	14%	14%	12%
Compressive strength(kg/cm²)	5.450	6.652	7.529	8.057
Strain	0.023	0.065	0.063	0.060

The above table shows the summary for sample black soil with addition of $Mgcl_2$

Table 7 Summary of results for Palm fiber

TEST EXPERIMEMT	BLACK SOIL + PALM FIBER			
Addition of palm fiber	0%	0.25%	0.5%	1%
Maximum dry density(g/cm^3)	1.750	1.855	1.956	2.172
Optimum moisture content	16%	16%	14%	12%
Compressive strength(kg/cm^2)	5.450	92.80	104.9	121.67
Strain	0.023	0.063	0.078	0.055

The above table shows the summary for sample black soil with addition of palm fiber. It has been noticed that there is increase in compressive strength at a proportion of 1 % of palm fiber.

6.1Comparative results:

6.1.1 Maximum Dry Density:

This test is done to determine the maximum dry density and the optimum moisture content of soil using heavy compaction as per IS: 2720 (Part 8) – 1983.

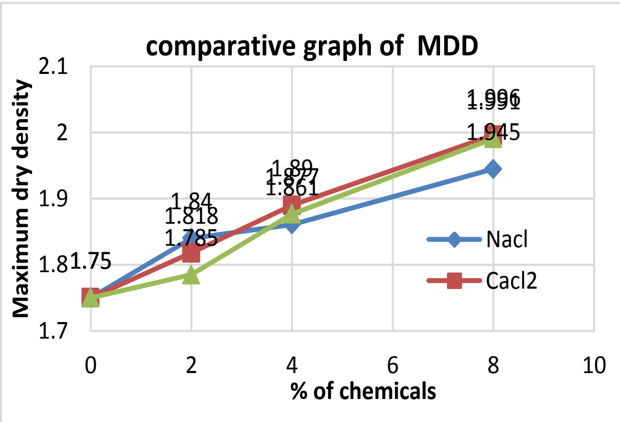

Figure 24: Maximum dry density of chemicals

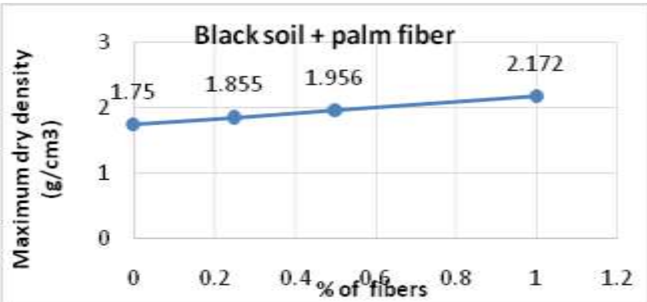

Figure 25: Maximum dry density of palm fiber

6.1.2 Unconfined compression test:

From the experimental results and from graphical output, it is inferred that when palm fiber is added to the soil sample there is an increase in the compressive strength value of at 1%.

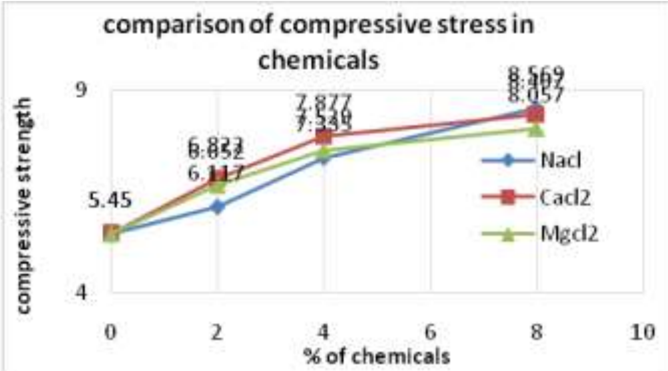

Figure 26: Compressive strength of chemicals

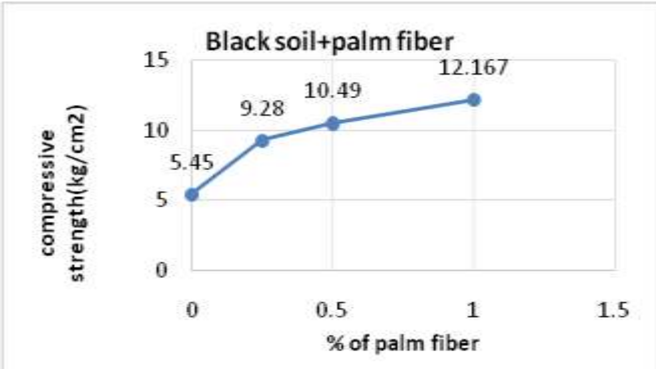

Figure 27: Compressive strength of palm fiber

Addition of palm fiber gave probable increase in strength values comparing to addition of chemicals in the soil. Hence 1 % of palm fiber can be used with soil to increase the strength, while the blend with 6 to 9% SCSA with addition of 6 to 9% biogases ash will give higher strength values. It was observed that by the addition of palm fiber for black cotton soil, the density has no significant changes, but the Compressive strength have been increased with the addition of 1% of palm fiber.

7. CONCLUSION

The use of palm fiber slightly improves the properties of expansive soils, palm fiber can be used as replacement in black cotton soil up to certain limits. It was observed that by the addition of palm fiber for black cotton soil, the density has no significant changes, but the UCC values have been increased with the addition of palm fiber. Addition of palm fiber gave probable increase in strength values comparing to addition of chemicals. The strength of these additives which has increased the black soil strength parameter and resulted to the usage in the foundation, road pavement construction etc. Based on the summary of results discussed above, it was concluded that palm fiber was an effective stabilizer than chemicals for improving the geotechnical properties of black cotton soil samples. By using the palm fiber, the construction methodology will be simple and can be maintained for longer time. It has the main advantage such as it will be economical for any type of construction and it mainly provides an eco- friendly environment by avoiding different type of pollution effects and from harmful hazards.

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BIOGRAPHIES

ASSISTANT PROFESSOR,

TRP ENGINEERING COLLEGE,

TRICHY, TAMIL NADU, INDIA.