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EXPERIMENTAL INSPECTION ON BLACK COTTON SOIL STABILIZATION BY USING SISAL FIBRE AND COPPER SLAG

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Abstract - Soil plays an important role in foundation of any structure. So the foundation provided should be stronger to withstand the load of whole structure. The presence of soil in the area of construction should be stable and strong for a better foundation. An expansive soil always creates problem more on lightly loaded structure than moderately loaded structure. In order to get rid of it, the soil is stabilized by adding sisal fiber and copper slag. So that, the strength of the soil will increase and the settlement rate will decrease. Copper slag with 1% to 4% as a constant is mixed with four different proportions of sisal fiber as 0.5,1,1.5 and 2%. The detailed observation of swelling and shrinkage behavior of clayey soil is assessed in a consecutive manner. In this direction, an experimental investigation of proctor compaction test, unconfined compressive test and direct shear was undertaken by adding sisal fiber and copper slag.

Key Words: soil stabilized, sisal fiber, Copper slag, direct shear, unconfined compressive test, proctor compaction test

1. INTRODUCTION

As a consequence of their inherent characteristics including low strength, high compressibility and a high potential for swelling and shrinkage, expansive soils are often characterized as unsuitable constriction material for civil engineering applications (Nalbantoglu, 2006). The main aim of stabilization is cost reduction and to efficiently use the locally available material. Therefore, such soils often require modification to satisfy design criteria prior application.Stabilization of expansive soils can be achieved through two approaches, i.e. chemical and mechanical techniques. Chemical techniques mainly involve the addition of chemical binders to the soil, there by amending the soil fabric into a coherent matrix of restricted have and induced. The mechanical approach makes use of compaction with the aid of reinforcement. Common reinforcement includes fibre of synthetic (e.g.Sisal fibre) and natural (e.g. Coir and palm) origin or other fibre like materials such as plastic waste strips and shredded tires. Within these stabilizations synthetic sisal fibre are used, because it possesses high tensile strength. Among the stabilization techniques, varies proportion of materials are added for this research, particularly based on the aspect ratio. And the theme of project is to stabilize the soil by adding the copper slag and sisal fibre. This process is done to improve engineering properties of the poor ground particles of expansive soil. In many cases, the top layers of most soil constitute large amount of organic matters. However, in well drained soils organic matter may extend to a depth of 1.5 m (Sherwood, 1993). Soil organic matters react with hydration product e.g. calcium hydroxide (Ca(OH)2) resulting into low pH value. The resulting low pH value may retard the 10 hydration process and affect the hardening of stabilized soils making it difficult or impossible to compact. he use of calcium-based stabilizer in sulphate-rich soils causes the stabilized sulphate rich soil in the presence of excess moisture to react and form calcium sulpho aluminate (ettringite) and or thamausite, the product which occupy a greater volume than the combined volume of reactants.However, excess water to one initially present during the time of mixing may be required to dissolve sulphate in order to allow the reaction to proceed (Little and Nair, 2009; Sherwood, 1993).

2. MATERIAL

2.1Soil

In this paper, the soil sample were collected from unstabilised region in the zone of Reddypalayam, Erode District. The obtained soil region is unsuitable for the construction. Based on the Studies, the soil was obtained at the depth of 1.5m below the ground level. And this has been further allowed to determine Engineering index properties of the soil sample.

Fig -1: soil sample

2.2COPPER SLAG

Copper slag is granulated cohesion less sandy sized material with the appearance of dark black color. During the extraction of Copper by melting Process, Copper Slag is obtained. This Slag is obtained by Quenching the Molten Metal in Water that produces Angular Granules of the Copper Slag. It is Composed of Oxides of Silicon and Iron. It can be used as a partial replaceable material to the Soil (Ali Behnood et. al, 2015). By the Sieve analysis test, the copper slag comes under Silty Sand classification. It exposes the clear representation on the additional friction to the soil particles.

Fig -2: Copper Slag

2.3SISAL FIBRE

Sisal fibre is fully biodegradable, green composites were fabricated with soy protein resin modified with gelatin. Sisal fibre. Modified soy protein resins, and composites were characterized for their mechanical and thermal properties.it is highly renewable resource of energy. Its fibre is too tough for textiles and fabrics. It is not suitable for a smooth wall finish and also not recommended forwet areas. The fine texture of sisal takes dyes easily and offers the largest range of dyed colours of all natural fibres. Zero pesticides or chemical fertilisers used in sisal agriculture.it is used in automotive friction parts (brakes, clutches), where it imparts green strength to performs, and for enhancing texture in coating Application.

Fig -3: Sisal fibre

Table -1: Physical Properties of normal soil

S.NO	Properties	Value
01.	Specific Gravity	2.56
02.	Soil Classification	Highly cohesive (CH)
03.	Plastic Limit (%)	26
04.	Liquid Limit (%)	75
05.	OMD (%)	17
06.	MDD (kN/ m^3)	1.50
07.	MBD (kN/ m^3)	1.71
08.	Shear Strength (kN/ m^2)	1.88
09.	Cohesion (kN/ m^2)	6
10.	Angle of Internal Friction (Deg)	5
11.	Permeability (mm/Sec)	0.000109
11.	Free Swell Index (%)	50

Table -2: Physical Properties of Copper Slag

S.NO	PHYSICAL PROPERTIES	VALUES
01.	Particle Size	Irregular
02.	Appearance	Black & Glassy
03.	Specific Gravity	2.99
04.	Bulk Density	45%
05.	Fineness Modulus	2.08 g/cc
06.	Angle of Friction	3.86
07.	Water Adsorption	0.4%
08.	Moisture Content	0.1%

Table -3: Physical Properties of Sisal Fibre

Property of fibre	Value
Colour	White
Average Diameter (mm)	0.25
Average Tensile Strength (N/mm2)	407.4
Density(g/cc)	1.47
Unit Weight (kg/m3)	964
Specific Gravity	0.964

3. RESULT AND DISCUSSION

3.1NANOPARTICLE ANALYSIS

It is an analytical technique used for the element analysis of a sample. It relies on an interaction of some source of x-ray excitation and a sample.Its characterization capabilities are due in large part to the fundamental principle that each element has a unique atomic structure allowing a unique set of peaks on its electromagnetic emission spectrum to stimulate the emission of characteristic X-rays from a specimen, a high- energy beam of charged particles such as electrons is focused into the sample being studied. And for this test, the results are also been concluded.

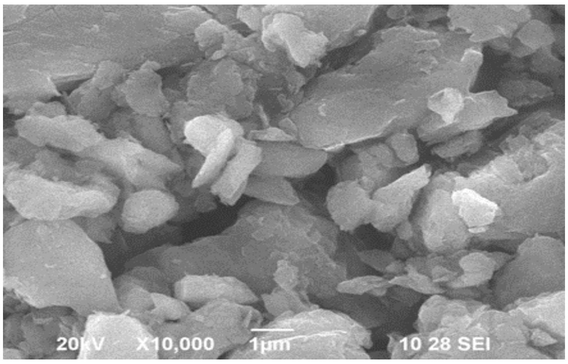

Fig-4:SEM Image for soil at 1µm

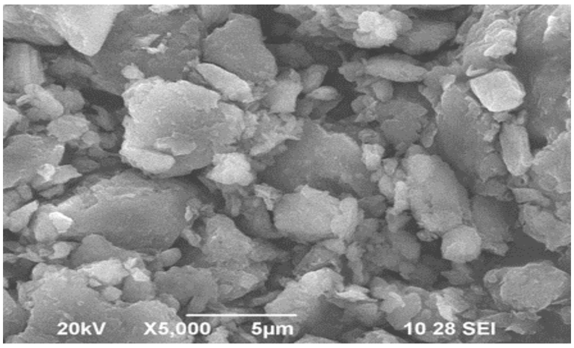

Fig-5:SEM Image for soil at 5µm

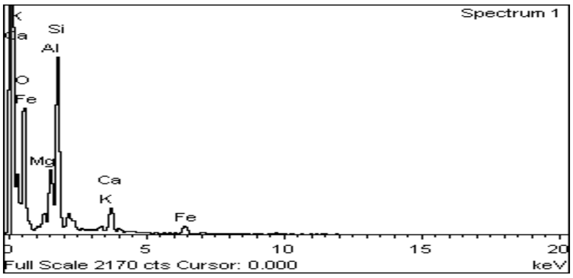

Fig-6: EDAX Image for soil

3.2 Particle Size Distribution Curve for Unstabilized Soil Sample.

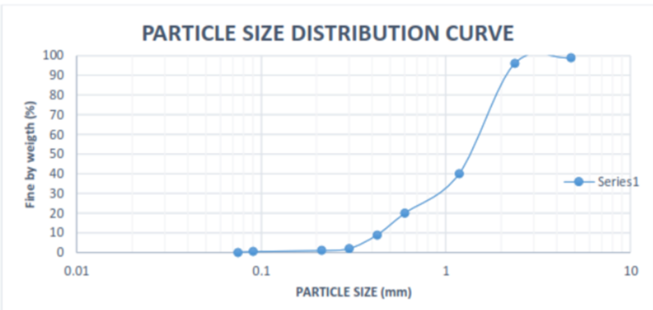

Fig-6: Particle Size Distribution Curve for Unstabilized Soil Sample.

From the sieve analysis result for the unstabilized soil it has been concluded that the taken soil sample is of highly cohesive soil (CH) as per the soil classification.

3.3Hydrometer Result for Normal Soil

On taking the soil sample retained from the pan and doing hydrometer analysis it is found that the clay content present in the sample is about 35%.

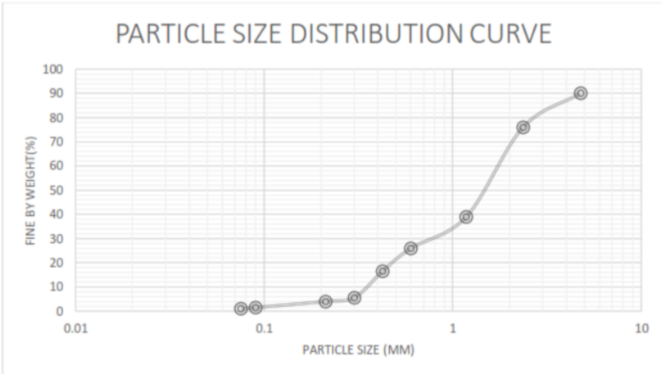

Fig-7: Particle Size Distribution Curve for copper slag

3.4 Mix Proportions for Stabilization

Based on these studies, the materials are contributed as per the terms of aspect ratio depending upon their Geometrical properties. The length of Polypropylene fibre is maintain in yield of effective stabilization with corresponding the field conditions, the proportions range is adopted with appropriate aspect ratio of Polypropylene as constant of 1% to 4% by varying the proportions of Copper Slag as 1%, 2%, 3% and 4% (i.e., 0.5%S.F+1%C.S :1%S.F+4%C.S : 1.5%S.F+4%C.S : 2%S.F+4%C.S).Within these consideration, there were 16 mix proportion ratio are been evaluated. For every varying aspect ratio, OMC & the Proctor test is done to determine the maximum density to achieve further laboratory test. For this density range, unconfined compression test, Direct Shear Test, Swelling Test are also achieved. Hence, based on the studies, the effect of soil with Non-Destructive additives has been investigated.

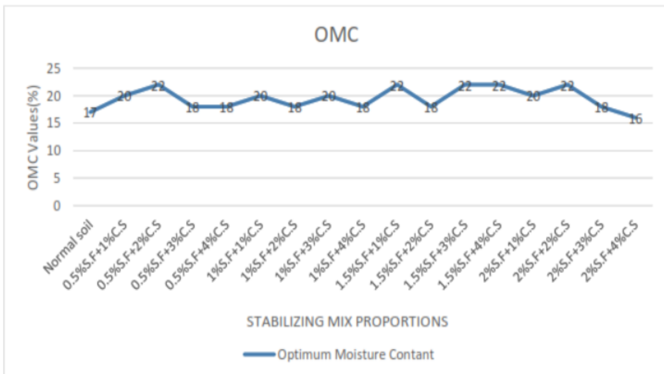

Fig-8: Specific Gravity for Normal Soil+ Mix Proportionate

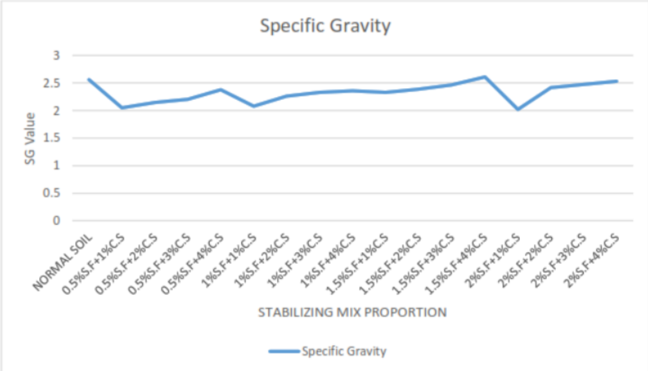

Fig-9:OMC for Normal Soil+ Mix Proportionate

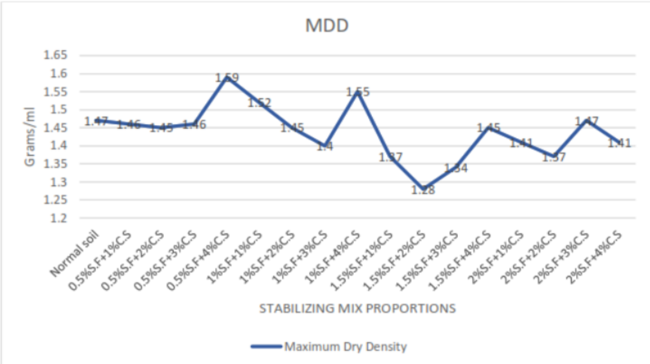

Fig-11:MDD for Normal Soil+ Mix Proportionate

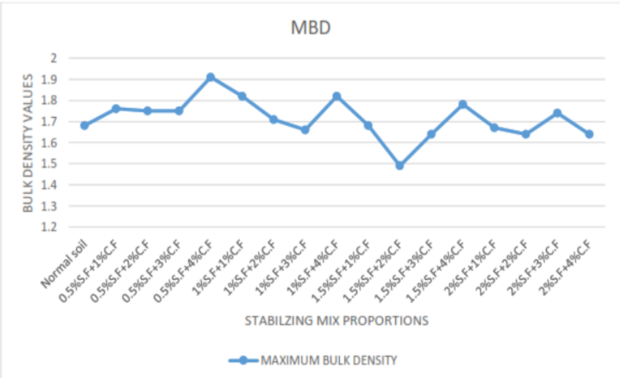

Fig-12: MBD for Normal Soil + Mix Proportionate

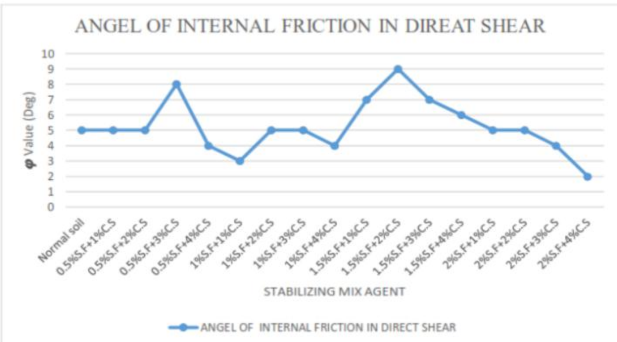

Fig-13: Angle of Repose for Normal Soil+ Mix Proportionate

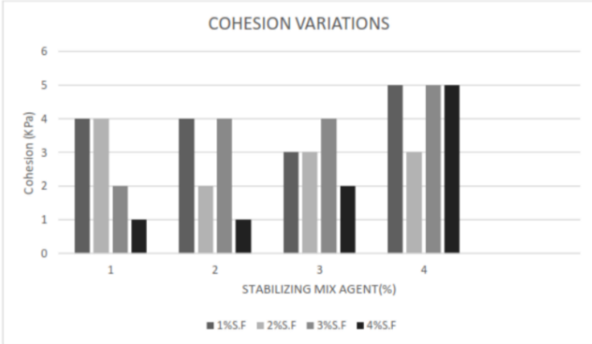

Fig-14: Cohesion Variation for Mix Proportionate

3.5 Specific Gravity for Normal Soil+ Mix

The test result for specific gravity for the mix proportion shows that MIX 12 (1.5%S.F+4%C.S) has the highest specific gravity of 2.61 than that of the normal soil.

3.6Free Swell Test

Table -4: Free Swell Test

S.NO	Mix Proportionate	Volume Increased in Water,(V_w) [cm^3]	Volume Increased in Kerosene,(V_k) [cm^3]	Swell Index (%)
01.	Normal Soil	12	8	50
02.	Mix – 06	10	7	42.85

The swelling index of the normal soil has been decreasing from normal soil to the mix proportions of the soil.

CONCLUSIONS

- From the result of the work it was possible to determine the strength of sisal fiber reinforcement with an mineral admixture to achieve a specific possibility in stabilization.
- A series of direct shear tests were applied to black cotton soil treated with various percentage of sisal fiber to copper slag ratio.
- The percentages of slag added to the soil were 1%, 2% and 3%, and 4% the results showed good potential for the application by increasing the shear friction angel from 2^0 up to 9^0whenever the angel of internal friction ranges high the magnitude of load intensity between the each particles gets higher.
- The corresponding maximum dry density from proctor test was found to be increased from 1.28 g/cu.cm to 1.59 g/cu.cm. clearly stated that the formation of soil matrix after treatment of copper slag with sisal fiber for 0.5: 4 % ratio gives optimum result by increasing load carrying capacity compared to untreated soil and MDD result is

directly proportional to settlement against normal load is fair proved from Unconfined compression strength test resulted 15.505 n/sq.cm for fair combination.

- Other than strength characteristics consistency parameters results give firm report against the untreated soil by resulting decreased in plasticity index from 44% to 30% was found, free swell index was decreased from 104% to 66%.
- The EDAX results shows the peak value count for ca- representWollastonite. Wollastonite is an industrial mineral comprised chemically of calcium, silicon and oxygen.
- Its molecular formula is $CaSiO_3$ and its theoretical composition consists of 48.28% CaO and 51.72% SiO_2. Portland cement consists essentially of compounds of lime contains calcium oxide, CaO mixed with silica silicon dioxide, SiO_2 and alumina aluminum oxide, Al_2O_3. From the result of EDAX it is clearly stated that sisal fiber capable to react and give binding action after complete reaction in soils also helps to fill the minor pores and strength the soil mass.

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