International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-4, November 2019

Lab scale Footing Analysis on Stabilization of Black Cotton Soil

V. Preetha, V. M. Gnanasundar, M. Arulsurya, R. Ramya, S. Nayannathara

Abstract: ***Expansive soil implies low bearing capacity and high swelling property perhaps causes serious problems during construction includes low stability, non-uniform settlements and shear distribution. The soil stabilization is one such method to improve the process and it depends upon the soil condition and the nature of soil according to the desired requirements of footing. This study aims to increase the index and engineering properties of soil by addition of the natural fiber (sisal), lime and silica fume. Soil stabilization by lime involves the admixture in the form of calcium oxide or calcium hydroxide to the soil and silica fume as an industrial waste by product acts as a pore filling material. The project is economically viable because the stabilizing materials are easily available and less cost. This project is also analyzed by using the PLAXIS software.***

Keywords: Black cotton soil, Stabilization, Index Properties, sisal fiber, silica fume, lime, PLAXIS.

I. INTRODUCTION

Stabilization is a process of alteration of soil to enhance its physical properties. Stabilization process increases the shear strength of a soil and or controls the shrink-swell properties of a soil, in order to improve the load bearing capacity of a soil applicable for pavements and foundation. Soil stabilization can be employed on roadways, parking areas, site development projects, airports and many other situation where soil sub grade are not suitable for construction. Stabilization process is accomplished by using wide variety of cemtitious admixture also whereas here the sisal fibers are used in addition to increase the tensile strength and bonding behavior of the material. Soil stabilization aims to improve the strength of the soil and raise the resistance to softening by water through bonding property of the soil particles. The simplest stabilization processes involves compaction of soil and drainage of water from drain pores. The process to improve gradation of particle size and further to improve by adding binders to the weak soils is one such way of soil stabilization accomplished by several methods. Expansive soil generally has low bearing capacity, high swelling property due to water absorption. Plastic limit, liquid limit are varied by water absorption of soil. It causes the serious problem during construction of building and pavement. Nowadays pavement and building requires the desired soil properties to increase the index property and engineering properties of soil by applying the natural fiber (sisal) and lime, silica fume added. In this project, the lime, silica fume and natural fibers are utilized.

Manuscript published on November 30, 2019.
* Correspondence Author
Preetha.V*,Civil Department , Bannari Amman Institute of Technology, Sathyamangalam,Tamil Nadu,India.
Gnanasundar V.M, Civil Department , Bannari Amman Institute of Technology, Sathyamangalam,Tamil Nadu,India..
ArulSurya M, Civil Department , Bannari Amman Institute of Technology, Sathyamangalam,Tamil Nadu,India.
Ramya R, Civil Department , Bannari Amman Institute of Technology, Sathyamangalam,Tamil Nadu,India.
Nayannathara.S, Civil Department , Bannari Amman Institute of Technology, Sathyamangalam,Tamil Nadu,India.

II. LITERATURE REVIEW

Dhananjay kumar et.al [1] conducted laboratory test to evaluate the stabilization properties of black cotton soil with stone dust and polypropylene fiber. They have conducted standard proctor test, unconfined compressive strength and atterberg limit. From the test results, they have conducted that the proposed methodology is very effective for improving engineering properties of black cotton soil.

Sandyarani [2] evaluated the properties of stabilization of black cotton soil by using sisal fiber. They analyzed the behavior of strength gain in sisal fiber stabilization by conducting various test .They have conducted specific gravity test, moisture content test, atterberg limit, well sieve analysis, free swell test, California bearing test. By analyzing this test, they concluded that unconfined compressive test and California bearing ratio test increases at percent of 0.5% sisal fiber.

Pallavi H N [3] investigated the expansive soil treated with and without lime as an ecofriendly stabilizer RBI-81.The soil mixes were tested for Unconfined Compressive Strength, California Bearing Ratio and Indirect Tensile Strength. The RBI-81 stabilizer was added in various percentages such as 2%, 4%, & 6%) to the soil and tested after curing for different periods. The Results indicate that optimum percentage as 4%. However the soil-RBI mixtures had low CBR strength and zero tensile strength. Conventionally, lime is used to improve the strength and reduce swell shrink of an expansive soil. Lime was added to soil treated with 4% RBI after determining Initial consumption of lime (ICL) as 6%. The results indicate that addition of lime to soil–RBI-81 mixtures significantly increased the compressive strength, indirect tensile strength and CBR value.

III. PROPERTIES OF BLACK COTTON SOIL

Black cotton soils are reddish brown to black in color and it occurs at a depth ranging from 0.5m to 10m and has high compressibility. Black Cotton soil in form of clay with medium to high compressibility forms as a major soil group. Black Cotton soil also known as expansive soil with high percentage of clay. Due to its remarkable swelling and shrinkage characteristics, it poses major challenge to civil engineering construction works.

The soils possess enough strength when it is dry, loses its strength during wet condition. The major contributing factors for the influence on behavior of expansive soil are moisture content, initial dry density, Atterber'g limits of the soil, and swell potential. The black cotton soils are found to have the following chemical composition

Table: 1 Chemical composition of black cotton soil

Property	Range
pH Value	>7(Alkaline)
Organic Content	0.4 to 2.04 %
$CaCO_3$	5 to 15 %
SiO_2	50 to 55 %
SiO_2 , Al_2O_3	3 to 5 %

IV. PROBLEMS ASSOCIATED WITH BLACK COTTON SOIL

Black Cotton soils are problematic for engineers universally in the world, and more so in tropical countries like India because of wide temperature variations and climatic changes, leading to wide variations in moisture content of soils. The following problems generally occur in black cotton soil are as follows.

1. High compressibility
2. Swelling
3. Shrinkage
4. Negative impacts of shrinkage
5. Water seepage problems
6. Bearing capacity failure
7. Uneven consolidation

The properties of soil, is a primary interest to the geotechnical engineering, but are indicative of the engineering properties are called index properties. This includes particle size analysis, specific gravity, Atterberg's limit, liquid limit, plastic limit and shrinkage limit. The main engineering properties of soil are permeability, plasticity, compaction, compressibility and shear strength.

V. SOIL STABILIZATION

Stabilization can increase the shear strength of a soil and or control the shrink-swell properties of a soil, thus improving the load bearing capacity of a sub-grade to support pavements and foundation. The simplest stabilization processes are compaction and drainage (if water drains out of wet soil it becomes stronger. The Stabilizing agents commonly used as binders are Cement, Copper slag, Fly ash, Blast furnace slag, Lime. The black soils are also called regur and black cotton soils because cotton is the most important crop grown on these soils. Black soils, locally called regard or black. Black cotton soils are generally black in color and occur from 0.5m to 10m deep ensures high compressibility.

VI. MATERIALS AND METHODOLOGY

Sisal, a natural fiber as shown in figure: 1 are fully biodegradable and highly renewable resource of energy. Treated fiber is exceptionally durable and having low maintenance with minimum wear and tear.

Figure: 1 Sisal Fiber

Lime or calcium – as shown in figure:2 contains inorganic mineral in which carbonates, oxides and hydroxides predominate in the strict sense of the term, lime are calcium oxides and calcium hydroxide it's also the lime xenoliths in volcanic erection. The color of most limes is varying shades of grey and tan. The greyness is caused by the presence of carbonaceous impurities-and the tan by the presence of iron. It has been found that all limes are crystalline but with varying crystal sizes, uniformity, and crystal arrangement. Silica fume is an industrial byproduct in the carbo thermic reduction of high purity quartz with carbonaceous materials like coal, coke, wood-chips, in electric arc furnaces in the production of silicon and ferrosilicon alloys.

Figure: 2 Lime

Silica fume a by- product in the carbothermic reduction of high purity quartz with carbonaceous materials like coal, coke, wood-chips, in electric arc furnaces in the production of silicon and ferrosilicon alloys as shown in figure: 3.

Figure : 3 Silica fume

VII. EXPERIMENTALPROCEDURE

SIMULATION OF FOUNDATION MODEL

The instrumental load setup view of the experimental model is shown in figure: 4. for this study. The box setup with inside dimensions of 30 cm X 25 cm x 25 cm in depth, with wall thickness of 6 mm all around the box. The box is made to become stable enough to minimize displacement in all directions. The walls of the box frame are braced with wooden planks on the outer surface at the mid depth of the tank. The inside walls of the box frames are polished to reduce friction with the soil by using galvanized coating inside the wall. The loading system consist of hydraulic jack and pre-calibrated proving ring to apply the load manually to the footing soil system and the settlement was measured by using dial gauges fixed at footing surface.

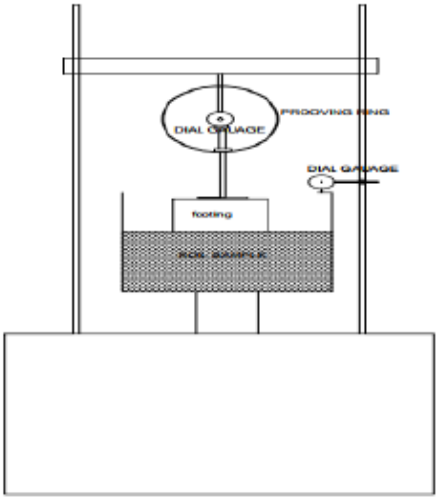

Figure: 4 Foundation model load setup

NANO PARTICLE ANALYSIS

1. SEM ANALYSIS

The morphological characteristic of various industrial wastes are carried out using SEM. The particles are composed of mixture of irregular and spherical shape with complex pore structure. Micro level particle analysis shows the texture of the chosen surface and individual micropology of the particle at different wave range for sisal fibers in figure: 5 and 6 , for lime in figure 7 and 8 , are classified.

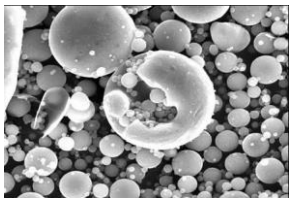

Figure:5 500µm

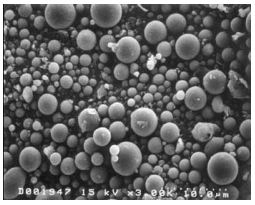

Figure:6 250µm

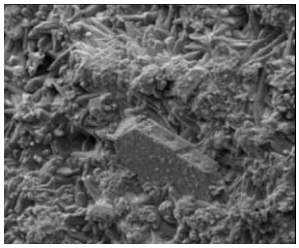

FIGURE:7 - 500µm

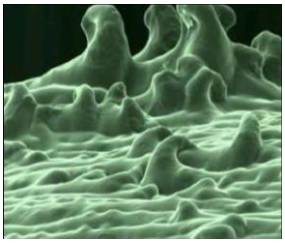

FIGURE: 8 - 500µm

2. EDAX RESULT

From the knowledge of EDAX result presence of silica, lime, sisal fiber, calcium are identified and make a proof for suggestion of particular industrial by product wastes as a stabilizer.

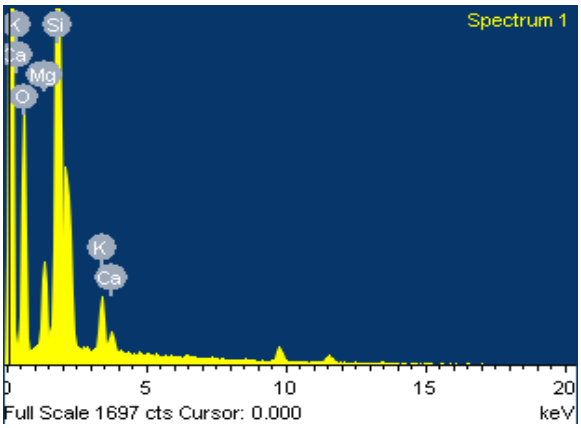

Figure: 9 EDAX result of silica fume

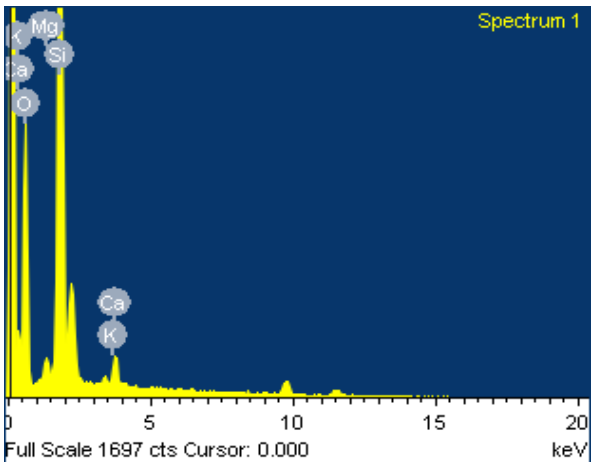

Figure: 10 EDAX result of Lime

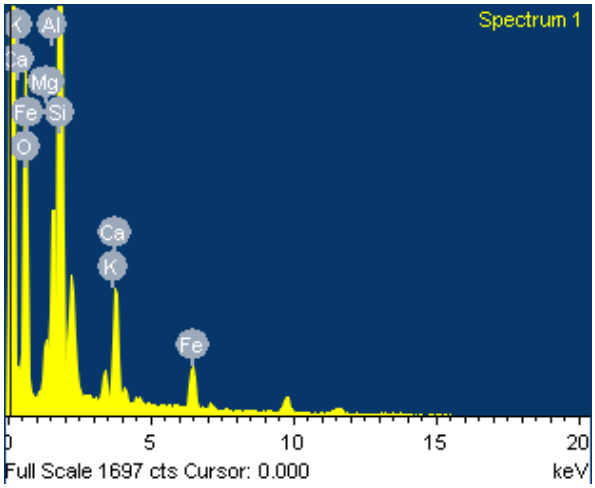

Figure: 11 EDAX result of sisal fiber

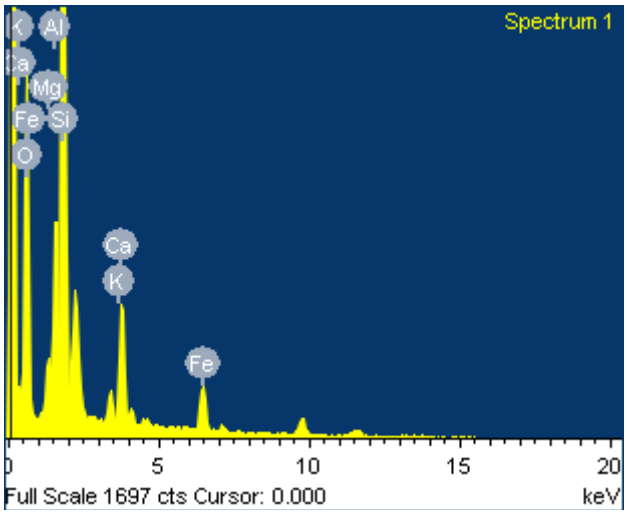

Figure: 12 EDAX result of black cotton soil

VIII. RESULTS AND DISCUSSION

The Basic test such as sieve analysis is performed to analyse the particle size distribution of granular materials and their results are in table 2.

Table: 2 Sieve analysis results

s.no	Is sieve size(mm)	Wt of retaining	% of retaining	Cumulative %	% of finer
1	4.75	120.6	12.06	12.06	87.94
2	2.36	114.5	11.45	23.51	76.49
3	1.18	356.3	35.63	59.14	40.86
4	0.6	89.4	8.94	68.08	31.92
5	0.425	84.3	8.43	76.51	23.49
6	0.300	70.3	7.03	83.54	16.46
7	0.150	97.9	9.79	93.33	6.67
8	0.75	40	4	97.33	2.67
9	Pan	23.7	2.37	99.78	0.3

Table: 3 Hydrometer analysis for normal soil

Hydrometer Time (min)	Analysing Reading (R_h)	Height (H_1)	R_h+Mt-x	H_R	D	W
1	19.6	20.2	17.5	21.09	0.017	31.84
2	18.8	20.5	16	21.39	0.012	29.12
4	18.2	20.5	16	21.39	$8.65*10^{-3}$	29.12
8	16	21.3	14	22.19	$6.23*10^{-3}$	25.48
16	12	21.7	11.5	22.59	$6.82*10^{-4}$	20.93
30	10.5	21.9	11	22.79	$3.67*10^{-4}$	20.02
60	6	22.4	9	23.29	$2.33*10^{-3}$	16.38
120	5.6	22.7	7.5	23.59	$1.65*10^{-3}$	13.65
240	4	23.2	5	24.09	$1.18*10^{-3}$	9.1
1440	1	24.3	2	25.19	$4.95*10^{-3}$	3.64

Table : 4 Mix proportions for stabilization

S.no	Mix Proportionate	Soil Sample (%)	Sisal fiber (%)	Silica fume+lime (%)
01.	Normal Soil	100	-	-
02.	Mix-1	98	1(1cm)	1
03.	Mix-2	97	1(1cm)	2
04.	Mix-3	96	1(1cm)	3
05.	Mix-4	95	1(1cm)	4
06.	Mix-5	97	2(1cm)	1
07.	Mix-6	96	2(1cm)	2
08.	Mix-7	95	2(1cm)	3
09.	Mix-8	94	2(1cm)	4
10.	Mix-9	98	1(2cm)	1
11.	Mix-10	97	1(2cm)	2
12.	Mix-11	96	1(2cm)	3
13.	Mix-12	95	1(2cm)	4

RESULTS FOR STABILIZED SOIL

The addition of various proportions of silica binders of stabilizing agent to soil with different percentages increases optimum moisture content. By Comparing with normal soil and stabilizing agent of mix 1% sisal fiber and 1% of silica and lime optimum moisture is low than the normal soil shows that the replacement of sisal by silica fume &lime in mix is completely vary.

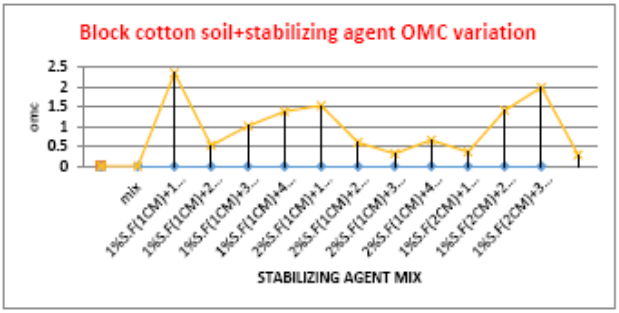

Figure 13: Moisture density relation

The dry density increases at optimum percentage of combination in Soil there after density reduces; this is due to critical change of the soil structure from flocculated state to dispersed state. Variation in mix is subjected next. The procedure is followed by proper energy calculation for obtained MDD. Maximum dry density with the addition of silica fume, sisal and other materials shows the variation of increase in optimum moisture content of soil and decrease in dry density value. From above result it was observed that mix is 1% of sisal and 2% of silica and lime and 2% of sisal and 1% of silica and lime combination is the optimum percentage at which the density increases and moisture content decreases.

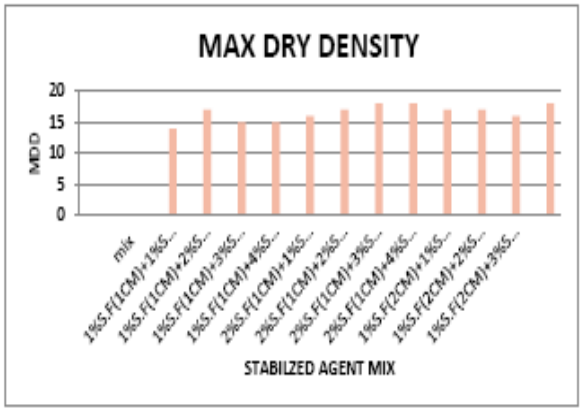

Figure: 14 Variation in maximum dry density

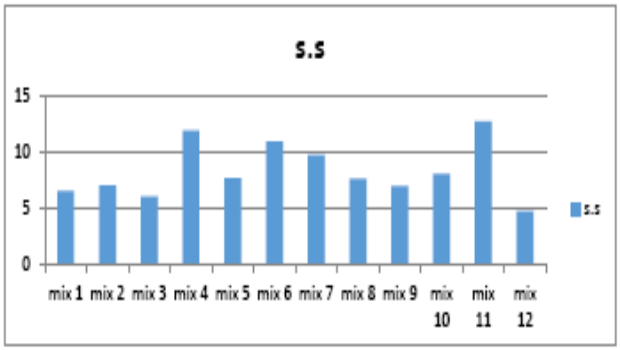

Figure: 15 shear strength for black cotton soil + stabilizing agent mix

From the results obtained shear strength of soil is high in mix 2, shows the resistance of the soil against failure is more for the soil stabilized with that. These samples are created for the maximum dry density.

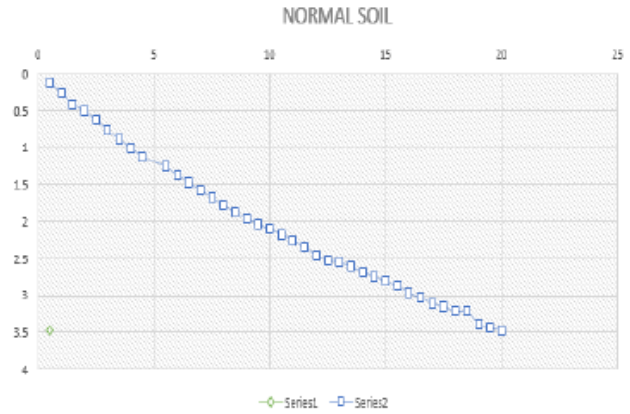

Figure : 16 Footing analysis for normal soil

It represents the compressive strength as an index qualification of effectiveness of an additive improvement of soil due to treatment. Additive of 20 % on soil yielded continuously increase in strength is shown in figure below with day increases. Improvement in strength is due to development of more cementations in stabilization action. .reinforced used on sisal fiber on increase the tensile strength of soil waste material of silica fume and lime are used to increase compression strength of soil . analysis the soil stabilization of footing check to photo type model of footing first step of analysis the need sample of soil then compare to the on other test of ucs , direct shear are select the mix ratio of soil is find then analysis the mix ratio is stable on compare the ordinary soil finally the result are analyzed using the PLAXIS software .

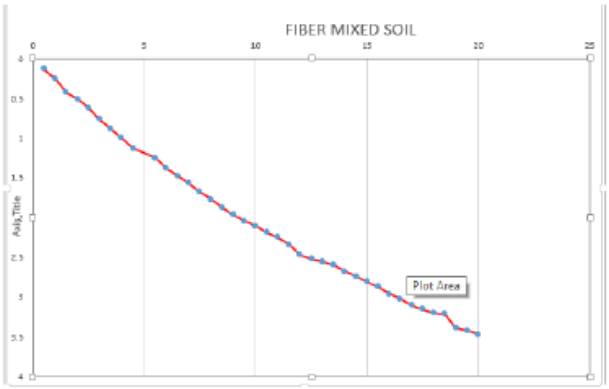

Figure : 16 Footing analysis for Fiber mixed soil

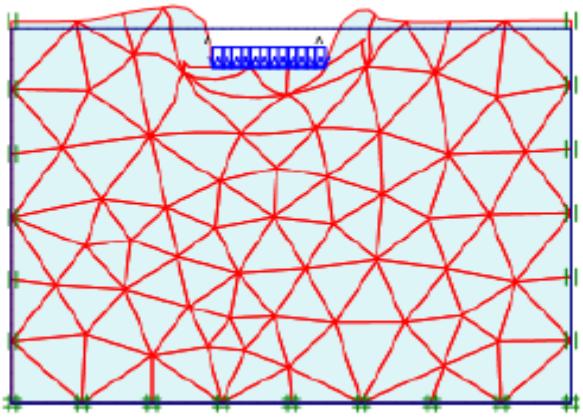

Figure: 17 Deformed mesh for normal soil

IX. CONCLUSION

From the investigation of the black cotton soil major defect is high swelling and shrinkage compare to the on other soil. So using natural materials analysis is done experimentally and compared with normal soil. Following are the conclusions are arrived based on the test results.

1. Effective interlocking of soil wedge obtained between the sisal fiber and the soil and the sub grade densification is achieved as a result the footing load increases and the settlement decreased.
2. Addition of sisal fiber increases the tensile strength of soil. The maximum dry density of stabilized soil increases and optimum moisture content decreased in addition to various percentage of fiber and length of fiber.

3. Silica fume acts as a void filling material. It is used to fill voids on black cotton soil and decrease the major defect of swelling of soil to avoid the settlement of footing.
4. The improvement the compressive strength of soil is by using lime as one of the binding material. The study rate of increase the strength will range from 20% to 30% its increase.
5. The improvement in the load carrying capacity of footing on reinforced loose subgrade was reached to 2.5 times of footing.
6. By increasing the angle of shear resistance of subgrade from 31^{o} to 41^{o} for reinforced footing reduced the settlement factor of flatted type as much as 150% of footing .Sharp decrease in the efficiency when the shear angle decrease and the values of the efficiency increase with increase in embedment depth.

REFERENCES

1. Dhananjay Kumar Tiwari , Dr. R.K.Dixit, Dr. Subrat Roy, "Study on Stabilization of Black Cotton Soil by Using Stone Dust & Polypropylene Fibers"IJIRSET,Vol 5, issue 9,sep 2016.
2. Sandyarani, Dr.Vageesha S Mathada, Sharanakumar, Stabilization of black cotton soil by using Sisal fiber,IRJET,vol-5,issue-8,aug 2018.
3. Pallavi H N , Sureka Naagesh, Effect of Addition of Lime on the Properties of RBI-81 Treated Expansive Soil Subgrade, IOSR Journal of Mechanical and Civil Engineering, Volume 12, Issue 2 Ver. III (Mar - Apr. 2015), PP 01-08.
4. G. O. Young, "Synthetic structure of industrial plastics (Book style with paper title and editor)," in Plastics, 2nd ed. vol. 3, J. Peters, Ed. New York: McGraw-Hill, 1964, pp. 15–64.
5. Y. Li, X. Ling, L. Su, L. An, P. Li, and Y. Zhao, "Tensile strength of fiber reinforced soil under freeze-thaw condition," Cold Reg. Sci. Technol., vol. 146, pp. 53–59, 2018.
6. Q. Chen and M. Abu-farsakh, "Ultimate bearing capacity analysis of strip footings on reinforced soil foundation," Soils Found., vol. 55, no. 1, pp. 74–85, 2015.
7. E. Elsaied, "Behavior of circular footing resting on laterally confined granular reinforced soil," HBRC J., vol. 11, no. 2, pp. 240–245, 2015.
8. J. B. Oza and P. J. G. P.- Email-, "Study of black cotton soil characteristics with cement waste dust and lime," Procedia Eng., vol. 51, no. NUICONE 2012, pp. 110–118, 2013.
9. Soltani, A. Deng, and A. Taheri, "Geotextiles and Geomembranes Swell – compression characteristics of a fi ber – reinforced expansive soil," Geotext. Geomembranes, vol. 46, no. 2, pp. 183– 189, 2018.
10. R. Sridhar, "A Review on performance of coir fiber reinforced sand," vol. 9, no. 1, pp. 249–256, 2017.

AUTHORS PROFILE

Preetha.V, Assistant Professor (Senior Grade), Department of civil Engineering, Bannari Amman Institute of technology, Sathyamangalam, Erode District.

Gnanasundar.V.M Assistant Professor, Department of civil Engineering, Bannari Amman Institute of technology, Sathyamangalam, Erode District.

Arul surya M, PG student, Department of civil Engineering, Bannari Amman Institute of technology, Sathyamangalam, Erode District.

Ramya R, PG student, Department of civil Engineering, Bannari Amman Institute of technology, Sathyamangalam, Erode District.

Nayannathara S, PG student, Department of civil Engineering, Bannari Amman Institute of technology, Sathyamangalam, Erode District.