Laboratory Study of Black Cotton Soil Blended with Lime and Fly-ash

[1]G. Sivapavani, [2]K. Abhiram, [3]G. Nikhil kumar, [4]T. Shravani, [5]A. Kumar
[1]Assistant Professor, [2,3,4,5]UG Student, Department of Civil Engineering
[1,2,3,4,5]Aurora's Technological and Research Institute, Uppal, Hyderabad

Abstract:- Black cotton soil is widely distributed in India, Maharashtra is mainly covering with Black cotton soil. Black cotton soil is having high swelling and Shrinkage Character in nature. Because of this heavily loaded structure like Dam, Bridge etc. are severely damaged. Its stabilization is required to mainly improve the Soil properties. In this paper Black cotton soil mainly stabilized using Fly ash and Lime. Combination of Fly ash and Lime proves to be very effective and cheaper method of stabilization. This paper also describes that if we add the admixture in Black cotton soil, we can improve the strength of soil as well as Stabilize the soil. In this project, soft clay was tested to find the optimum moisture, California bearing ratio (CBR) plastic limit and liquid limit vane shear compaction test etc. Fly ash and lime were added with varying percentages like 10%, 20%, 30%) for which maximum strength is obtained was found out

Keywords: -Black Cotton Soil, Soil Stabilization, Fly Ash, Lime.

I.INTRODUCTION

The study is being carried out mainly in Bhatgar dam, Pune. An experimental investigation is made to find the soil condition and conduct the lab test to find soil properties. For stabilization Lime and Flyash are used in different proportion. For lightly loaded structure swelling of soil will be more under any load. As a result there is asettlement of structure and differential movements, resulting into damage to foundation.

1.1 Fly ash:Fly ash is a byproduct from burning pulverized coal in electric power generating plants. As the fused material rises, it cools and solidifies into spherical glassy particles is fly ash. Fly ash is collected from the exhaust gases by electrostatic precipitators or bag filters.

1.2 Lime: It is a white powder and composed primarily of oxides and hydroxide, or "slaked" with water. Lime is used in large quantities as building and engineering materials, lime is derived from rocks and minerals typically limestone or chalk.

1.3 Literature Review

1) Kaniraj S R, Havanagi V G: In this paper, Rajghat fly ash from Delhi, India and Baumineral fly ash near Bochum, Germany, were mixed with the locally available soils silt and Yamuna sand withRajghat fly ash and Rhine sand with Baumineral fly ash in different proportions. Cement, varying from 3–9% was added to stabilize the fly ash-soil mixtures. Cylindrical samples were prepared at optimum moisture content and maximum dry density and were cured for different duration. Unconfined compression tests were conducted on these samples. Correlations for unconfined compressive strength and secant modulus as functions of curing time, fly ash content, and cement content have been established.Correlations for water content as functions of curing time and cement content have also been established [1].

2) Cokca E: In this study, high-calcium and low-calcium class C fly ashes from the Soma and Tuncbilek thermal power plants, respectively, in Turkey, were used for stabilization of an expansive soil. Lime and cement were added to the expansive soil at 0–8% to establish baseline values. Soma fly ash and Tuncbilek fly ash were added to the expansive soil at 0–25%. Test specimens

were subjected to chemical composition, grain size distribution, consistency limits, and free swell tests. Specimens with fly ash were cured for 7 days and 28 days, after which they were subjected to odometer free swell tests. Based on the favorable results obtained, it can be concluded that the expansive soil can be successfully stabilized by fly ashes [2].

3) Amer Ali Al-Rawas, Ramzi Taha, John D. Nelson, Thamer Beit Al-Shab, Hilal Al-Siyabi: This paper investigates the effectiveness of using cement bypass dust, copper slag, granulated blast furnace slag, and slag-cement in reducing the swelling potential and plasticity of expansive soils. The soil used in this study was brought from Al-Khod (a town located in Northern Oman) where structural damage was observed. [3].

4) Bell, F.G: Clay soil can be stabilized by the addition of a small percentage, by weight, of lime, that is, it enhances many of the engineering properties of the soil. This produces an improved construction material and so the technique has been used for many construction purposes, notably in highway, railroad and airport construction to improve subgrades and sub-bases. Generally the amount of lime needed to modify a clay soil varies from 1 to 3 per cent, whilst that required for cementation varies from 2 to 8 percent [4].

5)Karthik.S,Ashokkumar.E, Gowtham.P, Elango.G, Gokul.D, Thangaraj.S:
The objective of this study was to evaluate the effect of Fly Ash derived from combustion of sub-bituminous coal at electric power plants in stabilization of soft fine-grained red soils. California bearing ratio (CBR) and other strength property tests were conducted on soil. The soil is in range of plasticity, with plasticity indices ranging between 25 and 30. Tests were conducted on soils and soil–Fly Ash mixtures prepared at optimum water content of 9% .Addition of Fly Ash resulted in appreciable increases in the CBR of the soil. For water contents 9% wet of optimum, CBRs of the soils are found in varying percentage such that 3,5,6and 9.We will found optimum CBR value of the soil is 6%.Increment of CBR value is used to reduce the thickness of the pavement. And increasing the bearing capacity of soil [5].

6) Amu, O.O., Fajobi, A.B., Oke, and B.O: This research was meant to study the effect of Eggshell Powder (ESP) on the stabilizing potential of lime on an expansive clay soil. Tests were carried out to determine the optimal quantity of lime and the optimal percentage of lime-ESP combination; the optimal quantity of lime was gradually replaced with suitable amount of eggshell powder. The lime stabilized and lime-ESP stabilized mixtures were subjected to engineering tests. The optimal percentage of lime-ESP combination was attained at a 4% ESP + 3% lime, which served as a control. Results of the Maximum Dry Density (MDD), California Bearing Ratio (CBR), unconfined compression test and Undrained triaxial shear strength test all indicated that lime stabilization at 7% is better than the combination of 4% ESP + 3% lime [6].

7) Muntohar, A.S. and Hantoro, G:
When geotechnical engineers are faced with clayey soils, the engineering properties of those soils may need to be improved to make them suitable for construction. Waste materials such as fly ash or pozzolanic materials have been used for soil improvement. Recent research, based on pozzolanic activity, found that rice husk ash was a potential material to be utilized for soil improvement. The effects of the engineering properties of clayey soils when blended with lime and rice husk ash are the focus of this paper [7].

8) Phani Kumar, B. R, and Sharma, S.R.:
This note presents a study of the efficacy of fly ash as an additive in improving the engineering characteristics of expansive soils. An experimental program has evaluated the effect of the fly ash content on the free swell index, swell potential, swelling pressure, plasticity, compaction, strength, and hydraulic conductivity characteristics of expansive soil. The plasticity, hydraulic conductivity and swelling properties of the blends decreased and the dry unit weight and strength increased with an increase in fly ash content. The resistance to penetration of the blends increased significantly with an increase in fly ash content for a given water content. Excellent correlation was obtained between the measured and predicted undrained shear strengths [8].

9) Rajan, B.H., and Subrahmanyam, N.: Problems associated with the use of black cotton soil in India are usually caused by swelling and shrinkage on the absorption or depletion of moisture. The stabilization of the soil is therefore of importance and ways of overcoming the shrinkage and swelling characteristics are considered. Stabilizers such as cement and lime have been widely used to counteract these problems although to achieve greater economy It was found that the 28-day shear strength with such an admixture in the proportion 1:4.5 indicated that almost 50% savings in lime could be made with such an admixture compared with soil treated with only 12% lime [9].

II. OBJECTIVE

1. To study the properties of soil when stabilized with lime and fly ash in certain proportion
2. To analyze the characteristic of Fly ash and lime
3. To improve the Engineering properties of soil
4. To Determine the Effect of Lime and Fly ash used as stabilizing material in Black cotton soil.

III. MATERIALS &METHODOLOGY

a) Black Cotton Soil
b) Fly ash
c) Lime

Table 1 Properties of Black Cotton Soil

Properties	Results
Specific Gravity	2.71
Liquid Limit (WL)	47%
Plastic Limit (WP)	17%
Optimum Moisture Content	15%
Maximum Dry Density	1.658 g/cc
Unconfined Compressive Strength (qu)	84.12 kN/m^2
Cohesion (Cu)	42.06 kN/m^2

Methodology provides in detail on the basis of which experiments are carried out. The soil was collected from the Bhatgar dam in Bhor. The soil was air dried and the lumps in the soil is crushed.Then it is compacted or powdered so that the soil can pass through 425-micron sieve.

Preliminary tests were conducted on the materials as per I.S.Standards and specifications. Where the black cotton soil was initially tested for its physical and engineering properties. Fly ash and lime are varied accordingly with percentage to evaluate the characteristics of strength variation.

The main aim of the methodology is to

- To evaluate strength characteristic of Black cotton soil with different percentage of fly ash and lime with varying proportion.
- To improve the properties of the Black cotton soil by adding admixtures.
- To determine the effect of Fly ash, Lime as stabilizing agents on Black cotton soil.

3.1 Experimental work

Following laboratory tests have been carried out as per I.S.2720.The test was carried out on both natural soil and stabilized soil with fly ash and lime.

Tests conducted on Black Cotton soil

1.Liquid Limit

Liquid limit is defined as the moisture content at which soil begins to behave as a liquid material and begins to flow. The importance of the liquid limit test is to classify soils. Different soils have varying liquid limits. Also, once must use the plastic limit to determine its plasticity index.

2. Plastic Limit

Plastic limit is defined as the percentage of moisture content and expressed as a percentage of the percentage of the oven dried soil at which the soil can be rolled into the threads one-eighth inch in a diameter without the soil breaking into pieces. This is also the moisture content of a solid at which a soil changes from a plastic state to a semisolid state.

3.Standard and Proctor Test

Compaction is the process of densification of soil mass by reducing air voids under dynamic loading. This test is conducted in order to find out the optimum moisture content and maximum dry density of the soil.

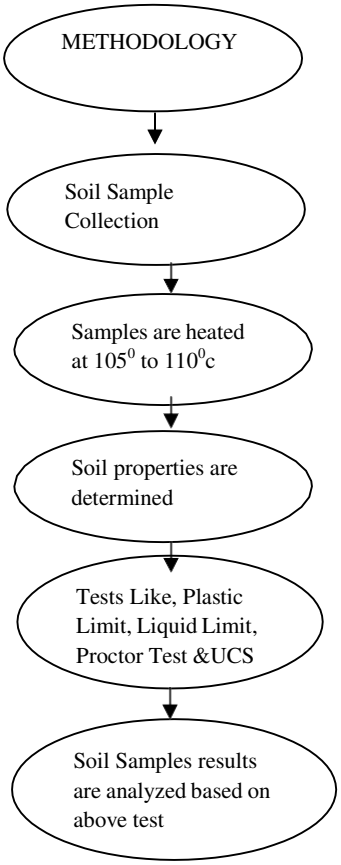
4. Unconfined Compression Test

The unconfined compression test is used to measure the shearing resistance of cohesive soils which may be undisturbed or remolded specimens. The shear strength of the expansive soil and the soil additive mixes were obtained by the unconfined compression tests performed according to IS.2720 part-10, 1991. An axial load is applied using either strain-control or stress-control condition. The unconfined compressive strength (UCS) is the maximum axial compressive stress that a right-cylindrical sample of material can withstand under unconfined conditions—the confining stress is zero. It is also known as the*uniaxial compressive strength* of a material because the application of compressive stress is only along one axis—the longitudinal axis—of the sample

3.2 Experimental Design

The proportion of Black cotton soil is determined and then the soil is stabilized with varying proportion of lime and fly ash.

1. Black cotton soil +10% Lime + 10% fly ash
2. Black cotton soil +20% Lime+20% fly ash
3. Black cotton soil +30% Lime+30% fly ash



IV. RESULTS

The soil samples have been investigated Geotechnical laboratory in our college for various Engineering properties. The results of the various routine tests and strength characteristics of soils found during investigations have already been mentioned above.

TABLE 2Test on Black Cotton Soil

Sr.No.	Name of Test		Result
1	Liquid Limit		29.5%
2	Plastic Limit		31.16%
3	Compaction	OMC	14 %
		MDD	1.859 gm/cc
4	Shear strength		0.973Kg/cm^2

TABLE 4Test on Black Cotton Soil for Combination of Lime andFly ash

Sl. No	Name of the test	10%L+ 10%F	20%L+ 20%F	30%L+ 30%F
1	Moisture content	27%	25.64%	18.88%
2	Plastic limit	17.52%	13.2%	11.34%
3	Liquid limit	28.34%	16.54%	14.37%
4	Compaction	1.517gm/cc	1.467gm/cc	1.427gm/cc
5	Shear strength	1.02kg/cm^2	1.21kg/cm^2	1.32kg/cm^2

CBR TEST

- The CBR value is 2.5 mm penetration is 3.95%
- The CBR value is 5 mm penetration is 2.94%

Standard Proctor Test The readings for different Percentage are as below:With the varying Constant % of Lime and Varying %of fly ash for the calculation of Maximum dry density & Optimum moisture content. It has been found that with the increase in percentage fly ash there is an increase in Maximum dry density values where as there is considerable reduction in optimum moisture content for the given soil.

Combination of fly ash and Lime showed a consistent decrease in the maximum dry density (MDD) and increase in optimum moisture content (OMC).

V. CONCLUSION

- By increasing in the percentage of lime and fly ash like ,0%,10% ,20%,30% the moisture content in the soil decreasing gradually (i.e.;29%,27%,25.64%,18.88%).
- Same as in the plastic limit, liquid limit if we increasing in the percentage of lime fly ash like 0%,10%,20%,30% the plastic limit (31.16%,17.525,13.02%,11.34%) and liquid limit (29.055,28.34%,16.54%,14.37%) value decreases gradually.
- In vane shear test if we increasing in the percentage of lime and fly ash like 0%,10%,20%,30% the shear strength is increasing respectively (i.e.; 0.973kg/cm2 ,1.02kg/cm2 ,1.21kg/cm2 ,1.32kg/cm2).
- In standard compaction test if we increase in the percentage of lime and fly ash like 0%,10%,20%,30% the dry density values are decreases gradually that is (i.e.;1.859gm/cc,1.517gm/cc,1.467gm/cc,1.427gm/cc).
- By increasing lime and fly ash in the sample the water content increases by decreasing dry density value.
- From CBR test the load on the soil is increases. As load increases bearing capacity of the soil increases.
- By adding lime and fly ash the shrinkage value decreases.

- Finally, we conclude that by replacement of soil with lime and fly ash the engineering properties of soil sample increases.

REFERENCES

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2.Soil mechanics by AURORA AND BINDRA

3.Ground improvement techniques by PURUSHUTAMA

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5.Geotechnical Engineering by V. N S. MURUTY

Code books: -

- Specific Gravity (IS 2720 Part-3)
- Particle Size Analysis (dry/wet) (IS 2720 Part-4)
- Liquid Limit (IS 2720 Part-5)
- Plastic Limit (IS 2720 Part-5)
- Shrinkage Limit (IS 2720 Part-6)
- Natural Moisture Content (IS 2720 Part 9)
- Differential / Free Swell Index (IS 2720 Part-40)
- Standard Proctor Compaction Test (IS 2720 Part –7)
- Modified Proctor Compaction Test (IS 2720 Part –8)
- Unconfined Compressive Strength (IS 2720 Part –10)
- Triaxial Shear Test (IS 2720 Part –11)
- Direct Shear Test (IS 2720 Part –13)
- California Bearing Ratio (CBR) Test (IS 2720 Part –16).