WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Stabilization of Black Cotton Soil using Lime, Fly Ash & Bio-Enzyme.

Komal Rushikesh Kolhe[(1)], Rushikesh Vilas Kolhe[(2)]

[1] Lecturer, Department of Civil Engineering, Amrutvahini Polytechnic Sangamner , Maharashtra 422608 .
[2] Assistant Professor, Department of Civil Engineering, Sanjivani College of Engineering ,Kopargaon, Maharashtra 423601 .
DOI : https://doi.org/10.55248/gengpi.6.0625.22107

A B S T R A C T

Engineers often face problem in construction on or with B.C. soil, due to its poor engineering performance i.e. high clay content, low strength and minimum bearing capacity. The poor performance of B.C. soil engineers has forced in search of stabilizing agent. As conventional stabilizer like, gravel, sand, cement are depleting and becoming expansive day by day. So it become necessary to look towards alternative ecofriendly and cost effective stabilizer. Recently bioenzyme (Terrazyme), Lime, Fly ash has emerging as effective stabilizer for stabilization. In this present paper soil sample were tested with bioenzyme, Lime and Fly ash. The result of Unconfined Compressive Strength (UCS), California Bearing Ratio (CBR), Consistency limit, Compaction test have been studied and discussed. It has been observed that there is significant improvement of engineering properties of B.C. soil with these stabilizers.

Key words: Black cotton (B.C.) soil, Bioenzyme, Terrazyme, Lime, Fly ash Soil Stabilization

1. INTRODUCTION

Maharashtra is a state located in West India. Maharashtra encompasses an area of 308,000 km² (119,000 mi²), and is the third largest state in India. The Western Ghats better known as Sahyadri are a hilly range running parallel to the coast, at an average elevation of 1,200 meters (4,000 ft). To the west of these hills lie the Konkan coastal plains, 50–80 kilometers in width. To the east of the Ghats lies the flat Deccan Plateau.

There are many multi-state irrigation projects in development, including Godavari River Basin Irrigation Basin. The plateau is composed of black basalt soil, rich in humus. This soil is well suited for cultivating cotton, and hence is often called black cotton soil. Western Maharashtra, which includes the districts of Nasik, Ahmadnagar, Pune, Satara, Solapur, Sangli and Kolhapur, is a prosperous belt famous for its sugar factories. Farmers in the region are economically well off due to fertile land and good irrigation.

1.1 BLACK COTTON SOIL & PROBLEMS ASSOCIATED WITH BLACK COTTON SOIL

It is a well-known fact that water is the worst enemy of road pavement, particularly in expansive soil areas. Water penetrates into the road pavement from three sides viz. top surface, side berms and from sub grade due to capillary action. Therefore, road specifications in expansive soil areas must take these factors into consideration. The road surfacing must be impervious, side berms paved and sub grade well treated to check capillary rise of water.

- Black Cotton soils absorb water heavily, swell, become soft and lose strength.
- These soils are easily compressible when wet and possesses a tendency to heave during wet condition.
- Black Cotton soils shrink in volume and develop cracks during summer. These properties make them poor foundation soils and earth construction material.
- The stability and performance of the pavements are greatly influenced by the sub grade and embankment as they serve as foundations for pavements.
- The wetting and drying process causes vertical movement in the soil mass which leads to failure of a pavement, in the form of settlement, heavy depression, cracking and unevenness.

1.2 SOIL STABILIZATION

Soil stabilization is the process of altering some soil properties by different methods, mechanical or chemical in order to produce an improved soil material which has all the desired engineering properties. 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.

1.2.1 OBJECTIVES

i)To increase the bearing power of the soil.

ii)To study the effect of bioenzyme, lime and fly-ash on properties of B.C Soil and its stabilization.

iii)To increase shear strength i.e. resistance to punching action of the soil.

iv)To increase flexibility in the soil to take the wheel load without deformation and cracking.

v)To reduce the tendency of swelling or increase in volume of the soil due to wetting and shrinkage on account of withdrawal of moisture.

vi)To increase the stability of earthwork in embankment as a whole.

1.3 SOIL STABILIZING AGENTS

1) Lime

Lime can be obtained in the form of quicklime or hydrated lime. Quicklime is manufactured by calcinations of limestone at high temperatures, which chemically transforms calcium carbonate into calcium oxide. Hydrated lime is created when quicklime chemically reacts with water. Lime can be used to stabilize clay soils and sub marginal base materials (i.e., clay-gravel, caliche, etc.). When added to clay soils, lime reacts with water in the soil and reduces the soil's water content.. Lime-stabilized sub grade and sub base materials can be used for very low to high traffic volume applications. Lime application rates are in the range of 2,950 to 4,200m2/day. The roadway lane should be closed during construction. If possible, it is recommended that the lane remain closed until a wearing surface can be applied.

2) Fly Ash

Fly ash is a residue of coal combustion that occurs at power generation and incineration plants in many countries. Fly ash can be used to

1) lower the water content of soils,

2) reduce shrink-swell potential,

3) increase workability, and

4) increase soil strength and stiffness.

3) Bio Enzyme

Enzymatic emulsions contain enzymes (protein molecules) that react with soil molecules to form a cementing bond that stabilizes the soil structure and reduces the soil's affinity for water. Categorically speaking, enzymatic emulsions work on a variety of soils as long as a minimum amount of clay particles are present. When applied at low application rates to the surface of the unbound road surface, enzymatic emulsions perform well for dust suppression. They bond soil particles together and so reduce dust generation. At higher application rates, enzymatic emulsions can be used to stabilize soils. Some of Bio enzyme are discuss below.

II. LITERATURE REVIEW

2.1 INTRODUCTION

Various Research were carried out to check the improvements in the properties of Black Cotton (BC) soil with bio enzymes , lime, fly ash. Some of the studies in short are mention below

2.2 REVIEW OF LITERATURE

Lekha et al. (1) have studied to check the improvements in the properties of Black Cotton (BC) soil with a non traditional stabilizer. The collected soil samples were treated with a commercially available bio enzyme and the treated soil samples were cured for different curing periods as 0, 7 and 28 days. The engineering properties obtained for different mix proportions of soil and the stabilizer are studied. The results of Consistency limits, FSI, UCS, CBR and Permeability test obtained for different curing periods under soaked and unsoaked conditions have been studied and discussed.

Lim et al. (2) have studied the soil road stabilization technologies for the extremes of dry and wet condition and discussed their positive impacts so as to convince the field engineers to adopt such technologies effectively in Malaysian rural areas. Such Roadways Designed For Low-Volume Traffic Are Constructed Of Local Soils Containing High Percentages Of Fines And High Indices Of Plasticity.

Vijay Rajoria et al.(3) have shown that stabilization of soil with bio-enzyme is evolutionary technique. Recently researchers used many bio-enzymes available for soil stabilization such as regolith, Permazyme, Terrazama, Fujibeton etc. which had been proven to be very effective and economical in soil stabilization. These bio enzymes satisfy the performance in its economical feasibility and serviceability criteria.

Puente Agarwal et al.(4)in their Study had carried out on the bio-enzyme namely Terrazyme, which had been used in their work to study its effect on the Unconfined Compressive strength of the Black Cotton soil having high clay content, low strength and minimal bearing capacity. Terrazyme is ecofriendly stabilizer and proves cost effective in soil stabilization. It had been found that Terrazyme treated Black Cotton soil shows significant increase in Unconfined Compressive strength with longer curing period.

Bergmann (5) has concluded through studies that Bio-Enzymes need some clay content to strengthen the soils. It was observed that at least 2% clay is needed for successful stabilization whereas 10 to 15% clay gave very good results.

Shukla et al. (6) they used Bio-Enzymes to stabilize five different types of soil ranging from low clay content to very high clay content, engineering properties and strength characteristics were determined and it was found that there is little to high improvement in physical properties. There was improvement in CBR and unconfined compression strength of soils like silty soil to sandy soil. An increase of 65 to 252% in UCS value was observed after 4 weeks of curing. Pavement design thickness also reduces to 25 to 40 percent.

Shankar et al.(7)studied the effect of different dosages of Bio-Enzymes on Lateritic soil of Dakshina Kannada (district of India), having liquid limit Plasticity Index more than 25% and 6% respectively. Tests were conducted on lateritic soil by adding different percentages of sand as well. They concluded that there is medium improvement in physical properties of lateritic soil. Therefore it was suggested that effect of Bio-Enzyme on soil should be examined in laboratory before actual field application. Higher dosage (200ml/2m3 of soil) produced 300% increase in CBR, 450% in unconfined compressive strength and permeability was reduced by 42% after four weeks of curing. It was also observed that enzyme is not effective for cohesion less soil.

III MATERIALS USED

The soil sample was tested with addition of stabilizing agent i.e. Bioenzyme by varying curing period from 0 to 4 weeks and dosages from 0.02 to 0.024ml per kg of soil. Then soil was tested for Unconfined Compression test (UCC). In next step the soil sample was tested with addition of stabilizing agent i.e. Lime. The addition of lime was varied from 1% to 6%.Then soil is tested for Unconfined Compression test (UCC). Then the soil sample was tested with addition of stabilizing agent i.e. Fly ash. The addition of fly ash was varies from 10% to 50%.Then soil is tested for Unconfined Compression test (UCC).

3.1 Black Cotton Soil

The term “black cotton” is believed to have originated from India where the locations of these soils favor cotton growth. For present investigation soil is collected from Shingnapur, Tal- Kopargaon, Dist- Ahilyanagar.

3.2 Bio Enzyme

One commercially available enzyme (Terrazyme) has been used in the present investigation. It is purchase from NATURE plus, Inc 55 Rachel Drive Stratford, Chennai. It is available as a concentrated liquid and is to be diluted with water in specified proportion before mixing with the soil.

3.3 Lime

Lime used in the present investigation was obtained from local distributer, Kopargaon, MH, India. Commercially available lime was dry and later sieved through I.S.425 micron sieve was taken for the study. The chemical composition of lime is given in Table1

Table 1 Chemical Analysis of Hydrated Lime

Chemical Characteristics	**Percentage (%)**
Silica	4.2
Insoluble matter	5.6
Ferric Oxide	1.7
Alumina	1.4

Calcium Oxide	51.7
Magnesia	0.7
Loss on ignition	30

3.4 Fly ash

The fly ash is collected from Thermal Power Plant Eklahare, Tal-Nashik, dist-Nasik.

Table 2Chemical composition of Fly ash

Constituent	**Percentage Range**
Silica (SiO2)	49-67
Alumina (Al2O3)	16-29
Iron Oxide (Fe2O3)	4-10
Calcium Oxide (CaO0	1-4
Magnesium Oxide (MgO)	0.2-2
Sulphur (SO3)	0.1-2
Loss on ignition	0.5-3

IV RESULT AND DISCUSSION

4.1 Test on Untreated Soil

Following test have carried out on untreated black cotton soil and tabulated in Table 3.

Table 3 Result of Untreated B.C. soil

Sr. No.	Property	BC soil
1	Specific gravity	2.26
2	Grain size distribution (%)	
	a) Gravel	5
	b) Sand	23
	c) Silt	56
	d) Clay	16
3	Consistency limits (%)	
	a) Liquid limit	59.93
	b) Plastic limit	30.18
	c) Plasticity index	33
4	IS Soil Classification	CH
5	Compaction test	
	a) MDD (g/cc)	1.15
	b) OMC (%)	63.63
6	Co-efficient of permeability	0.83x10-7

7	Unconfined compression test (KN/m2)	146
8	Free Swell Index (%)	48
9	California Bearing Ratio test (%)	10.1

4.2 Unconfined Compression Strength Test

4.2.1 The variation of UCS values with 0 to 6% of lime content are tabulated in Table 4.

Table 4 Variation of UCS for treated Soil with Lime

Lime Content (%)	**U. C. S. (KN/m^2)**
0	272.6
1	280.1
2	230.6
4	146.5
6	115.3

4.2.2 The variation of UCS values with 0 to 50% of fly ash content are tabulated in Table 5.

Table 5 Variation of UCS for treated Soil with Fly ash

Fly Ash Content (%)	**U. C. S. (KN/m^2)**
0	272.6
10	304
20	325
30	335
40	367
50	345

4.2.3 Variation of UCS for treated Soil with Bio enzyme

Table 6 Variation of UCS for treated Soil with Bio-enzyme

Curing Period (weeks)	**U. C. S. (KN/m^2)**
0	272.6
1	492
2	503
3	524
4	565

IV CONCLUSION

After performing the entire test on BC soil in laboratory with the addition of different stabilizing agents we are drawn some conclusion and recommendations as given in below.

i) UCS values increase with the increase in curing period and with increase in dosages of bioenzyme. This may be due to the reaction of enzyme with clay which results in cementation effect. It seen that there is increase in UCS value to 106%.

ii)It is observed that UCS values increases up to only 1% then the value goes on decreases with the increase in lime content.

iii)In case of fly ash addition it seen that there is increase in 35% UCS value for 40% fly ash.

V RECOMMENDATIONS

1. Bioenzyme is best stabilizing agent as compared to lime and fly ash and also has life time sustainability, so it can be used in Express ways and national highways.
2. Lime and Fly ash are cheaper materials and has considerable scope for construction of low cost road such as Village road.

VI. References

Lekha B. M, GouthamSarang, Chaitali N., Ravi Shankar A. U.(2013), “Laboratory Investigation on black cotton soil stabilized with nontraditional stabilizer ”,IOSR. JMCE Journal of Mechanical and Civil Engineering , eISSN 2278-1684, pISSN 2320-334X, pp 07-13.

S. M. Lim, D. C. Wijeyesekera, A. J. M. S. Lim, I. B. H. Bakar (2014), “Critical Review of Innovative Soil Road Stabilization Techniques”, IJEAT International Journal of Engineering and Advanced Technology, ISSN 2249 – 8958, Volume-3 Issue-5.

Vijay Rajoria, Suneet Kaur (Jan-2014), “A review on stabilization of soil using bio-enzyme”, IJRET International Journal of Research in Engineering and Technology eISSN 2319- 1163, pISSN 2321-7308.

Puente Agarwal, suneet kaur (May 2014),“Effect of bio-enzyme stabilization on unconfined compressive strength of expansive soil”, IJRET International journal of research in engineering and technology, eISSN 2319-1163, pISSN 2321-7308.

Bergmann, R (2000), "Soil stabilizers on universally accessible trails", USDA Forest Service, San Dimas Technology and Development Center.

Manoj Shukla, Dr. Sunil Bose and Dr. P.K. Sikdar, (2003), “Bio-Enzyme for Stabilization of Soil in Road Construction- A Cost Effective Approach”, IRC Seminar Integrated Development of Rural and Arterial Road Networks for Socio-Economic development, New Delhi.

A.U. Ravi Shankar, Harsha Kumar Rai, Ramesha Mithanthaya I. (2009), “Bio-enzyme Stabilized Lateritic Soil as a Highway Material”, JIRC Journal of Indian Road Congress, pp 553-557.

C. Venkatasubramanian, G. Dhinakaran, (2011),“Effect of Bio-Enzymatic Soil stabilization on unconfined compressive strength and California bearing ratio”, IJEAS International Journal of Engineering and Applied Sciences 6(5),pp 295-298.