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LABORATORY STUDIES ON BIO-ENZYME STABILIZED BLACK SOIL AS A HIGHWAY MATERIAL

SATHISH Y A
Asst. Professor, Dept. of Civil Engg.
S J C Institute of Technology
Chickballapur, Karnataka - 562101
yasathish7@gmail.com

KIRAN K M
Asst. Professor, Dept. of Civil Engg.
S J C Institute of Technology
Chickballapur, Karnataka - 562101
kiranthribhu@gmail.com

RAMYA B G
Asst. Professor, Dept. of Civil Engg.
S J C Institute of Technology,
Chickballapur, Karnataka - 562101
ramyabg09@gmail.com

RAVINDRA S L
Asst. Professor, School of Civil Engg.
REVA University, Yelahanka
Bengaluru, Karnataka - 560064
slravindra28@gmail.com

ABSTRACT

The abundantly available black soil in Chintamani taluk, Chickballapur district has higher Liquid Limit and Plastic Limit (LL ≤ 25%, PI ≤ 6%) than as specified by I.R.C. for Road Construction to be used as Sub-Base material. The basic properties of the natural soil were tested like Specific Gravity, Grain Size Distribution, Consistancy Limits, Unconfined Compression Strength, Permeability and CBR value. In addition if different proportions of Enzymes added to the soil then tests were conducted at different curing periods. One such stabilizing agent is Eco-Bond, which is used in the present investigation to stabilize the soil It has been observed that there is significant improvement in Unconfined Compression Strength(UCS) to the extent of 380% and CBR values increased by 250% and Coefficient of Permeability reduced by 42% at adding of Bio-Enzyme at a Dosage of 200ml per $2m^3$ of soil.

Keywords—bio-enzyme; eco-bond; stabilization; black soil; CBR; UCS

I. INTRODUCTION

Soil is the cheapest and the most widely used material in a Highway Construction, either in its natural form or in a processed form. Engineers are responsible for selecting or specifying the correct stabilizing method, technique and quantity of material required. Soils vary throughout the world and the engineering properties of soils are equally variable. The key to success in Soil Stabilization is Soil testing. The method of Soil Stabilization selected should be verified in the laboratory before Construction and preferably before specifying or ordering materials. Various techniques are being used for Stabilization of soil. Subgrade soil supports the different Pavement layers and the repeated Loads of traffic.

The growth of the population has created a need for Better and Economical vehicular operation which requires good Highway having proper Geometric Design, Pavement Condition and Maintenance. The Highways have to be maintained so that Comfort, Convenience and Safety are provided to the travelling public. Hence, it is necessary to have a proper diagnostic study of the soil to be used as sub-base. Cost effective roads are very vital for economical growth in any country. There is an urgent need to identify new materials to improve the road structure and to expand the road network. Commonly used materials are fast depleting and this has led to an increase in the cost of Construction. Hence, the search for new materials and improved techniques to process the local materials has received an increased impetus. When poor quality soil is available at the Construction site, the best option is to modify the properties of the soil so that it meets the Pavement Design requirements. This has led to the development of Soil Stabilization techniques. Since the nature and properties of natural soil vary widely, a suitable Stabilization technique has to be adopted for a particular situation after considering the soil properties. The objectives of any stabilization technique used are to increase the strength and stiffness of soil, improve workability and constructability of the soil and reduce the plasticity index.

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1.2 Mechanism of Soil Stabilization by Bio-Enzyme

In clay water mixture positively charged ions (cat-ions) are present around theclay particles, creating a film of water around the clay particle that remains attached orabsorbed on the clay surface. The absorbed water or double layer gives clay particles theirPlasticity. In some cases the clay can swell and the size of double layer increases, but itcan be reduced by drying. Therefore, to truly improve the soil properties, it is necessary topermanently reduce the thickness of double layer. Cat-ion exchange processes canaccomplish this. By utilizing fermentation processes specific micro-organisms canproduce stabilizing Enzyme in large quantity. These soil-stabilizing Enzymes catalyze thereactions between the clay and the organic cat-ions and accelerate the cat-ionic exchangewithout becoming part of the end product. [6] proposed a principle in which another NN yield input control law was created for an under incited quad rotor UAV which uses the regular limitations of the under incited framework to create virtual control contributions to ensure the UAV tracks a craved direction. Utilizing the versatile back venturing method, every one of the six DOF are effectively followed utilizing just four control inputs while within the sight of un demonstrated flow and limited unsettling influences. Elements and speed vectors were thought to be inaccessible, along these lines a NN eyewitness was intended to recoup the limitless states. At that point, a novel NN virtual control structure which permitted the craved translational speeds to be controlled utilizing the pitch and the move of the UAV. At long last, a NN was used in the figuring of the real control inputs for the UAV dynamic framework. Utilizing Lyapunov systems, it was demonstrated that the estimation blunders of each NN, the spectator, Virtual controller, and the position, introduction, and speed following mistakes were all SGUUB while unwinding the partition Principle.

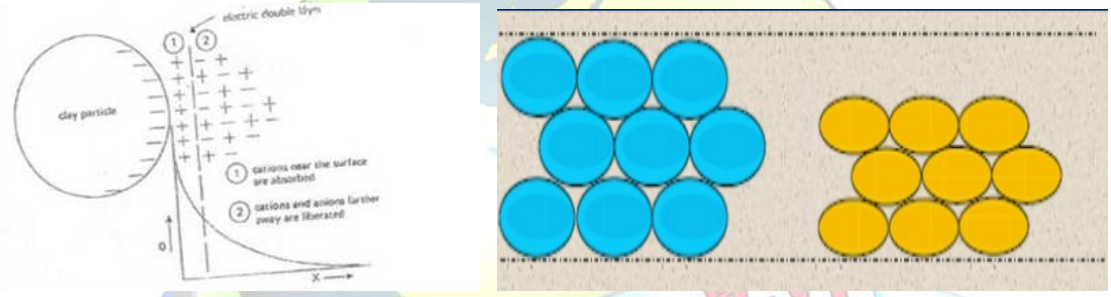

Figure 1.2: Mechanism of Enzyme Stabilization

Enzyme replaces adsorbed water with organic cations, thus neutralizing the negative charge on a clay particle. The organic cations also reduce the thickness of the electrical double layer. This allows enzyme treated soils to be compacted more tightly together.

Enzyme promotes the development of cementatious compounds using the following, general reaction:

$$H_2O + \text{Clay} \xrightarrow{\text{Enzyme}} \text{Calcium Silicate Hydrates}$$

II. METHODOLOGY

This chapter details the various tests conducted in the laboratory in order to study the characteristics of sub-base material. In the present study, samples were collected to assess the suitability of Bioenzyme (Ecobond) as soil stabilizer in black soil.

2.1 Materials

The soil used in this study is black soil, which is collected from Chintamani Taluk, Chickballapur district, Karnataka. Liquid stabilizer Bio-Enzyme (Eco-bond) is used as a admixture to stabilize the investigating soil.

Eco-bond is a low viscosity chemical, reactive gel or bio enzyme available as a liquid. Having almost the same viscosity as water, ECOBOND can permeate anywhere water can travel and cures within a controllable time frame anywhere from 5 seconds to ±10 hours or even days if slow curing is necessary. Once it cures, it creates an effective, long-lasting water barrier while providing superb soil stabilization. It will control ground water and stabilize soil permanently.Eco-bond is available in forms of bio-enzyme, polymer reactive gel and chemical type. All three have their own advantages in certain typical soils types.

2.2 Enzyme Dosage

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The enzyme dosage varies from 200 ml/3.5m^3 to 200 ml/2m^3 of the soil, and it depends upon soil properties. In this experimental investigation the Enzyme Dosages assumed for Expansive Clayey soil was 200 ml for bulk volume 3.5 m^3 to 1.5 m^3 of soil.

Bulk Density of BC soil = 2.054 g/cc
Bulk Density = Weight / Volume
Weight = Bulk Density x Volume

a) For Dosage 1

200 ml for 3.0 m^3 of Soil = 2.054 x 3.0 x 1000 = 6162 kg of Soil
For 1 kg = 200/6162= **0.033 ml** of Enzyme

b) **For Dosage 2**

200 ml for 2.0 m^3 of Soil = 2.054 x 2.0 x 1000 = 4108 kg of Soil
For 1 kg = 200/4108 = **0.047 ml** of Enzyme

Selected Curing Periods: 7, 14, 21 and 28 days (1, 2, 3 & 4 Weeks)

Table 2.2: Enzyme Dosages

Dosage	200ml/m^3 of soil	ml/kg of soil
1	3.0	0.033
2	2.0	0.047

III. EXPERIMENTAL RESULTS

3.1 Basic properties of Untreated Black Soil

Table 3.1 Properties of Untreated black soil

Sl. No.	Property	Value
1	Specific Gravity	
2	Grain Size Distribution	
	Gravel (%)	1.20
	Sand (%)	36.40
	Silt (%) + Clay (%)	62.40
	Co-efficient of Uniformity, Cu	4.42
	Co-efficient of Curvature, Cc	0.98
3	Consistency Limits (Atterberg Limits)	
	Liquid Limit (%)	45.4
	Plastic Limit (%)	33.79
	Plasticity Index	11.61
4	IS soil classification	MI – OI
5	Engineering properties	
	IS Light Compaction	
	MDD, kN/m^3	17.56
	OMC (%)	15.3
6	CBR (%)	
	IS Light Compaction(at OMC)	7.46
	IS Light Compaction (soaked)	2.05
7	Unconfined Compressive Strength IS Light Compaction (kPa)	142
8	Co-efficient of Permeability IS Light Compaction (cm/sec)	1.082 x 10^{-4}

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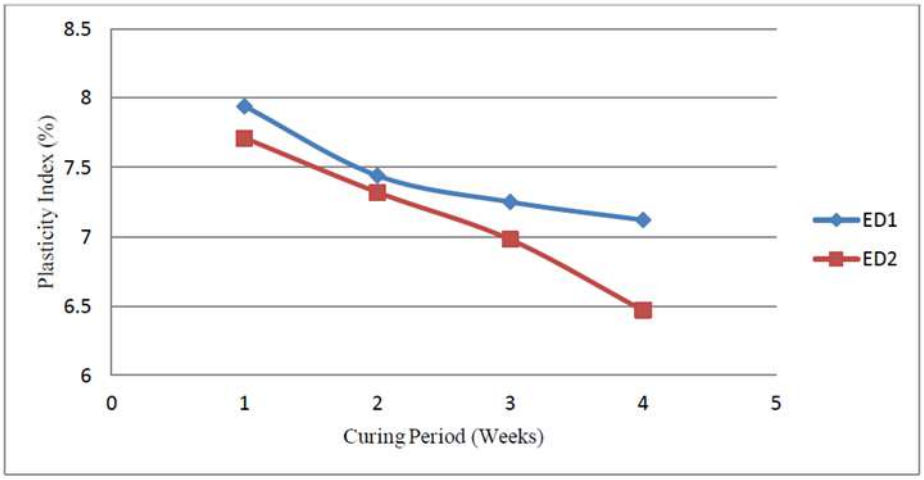
3.2 Consistency Limits

Liquid Limit and Plastic Limit of soil mixed with variable Dosage of Ecobond are tested after 1, 2, 3 and 4 weeks of curing. The effect of Bio-enzyme(Eco-bond) at different dosage on index properties (Liquid limit, Plastic limit and Plasticity index) of black soil have been presented in table no. 3.2.

Table 3.2: Consistency Limits of Soil Treated with Enzyme

Dosage	Consistancy Limits	Treated Weeks			
		1st	2nd	3rd	4th
1	LL	41.4	40.6	40.2	39.9
	PL	33.46	33.16	32.95	32.78
	PI	7.94	7.44	7.25	7.12
2	LL	41.2	40.2	39.6	39
	PL	33.49	32.88	32.62	32.53
	PI	7.71	7.32	6.98	6.47

Graph 3.2: Plasticity Index Vs Curing Period for treated soil



3.3 California Bearing Ratio (CBR) Test

Soil was treated with 2 Dosages of Enzyme at optimum moisture content. CBR moulds were prepared by standard proctors method and kept in airtight bags for testing on its 7, 14, 21 and 28 days curing. Later these moulds were kept in soaked condition for 4 days and then tested for CBR. CBR values of Black soil with different Enzyme Dosages in various curing days are given below table 3.3.

Table 3.3: CBR values of Soil Treated with Enzyme

Dosage		Treated Weeks			
		1st	2nd	3rd	4th
1	CBR (%)	2.5	3.0	4.0	5.0
2		3.5	5.0	6.0	7.0

Graph 3.3: CBR Vs Curing Period for treated soil

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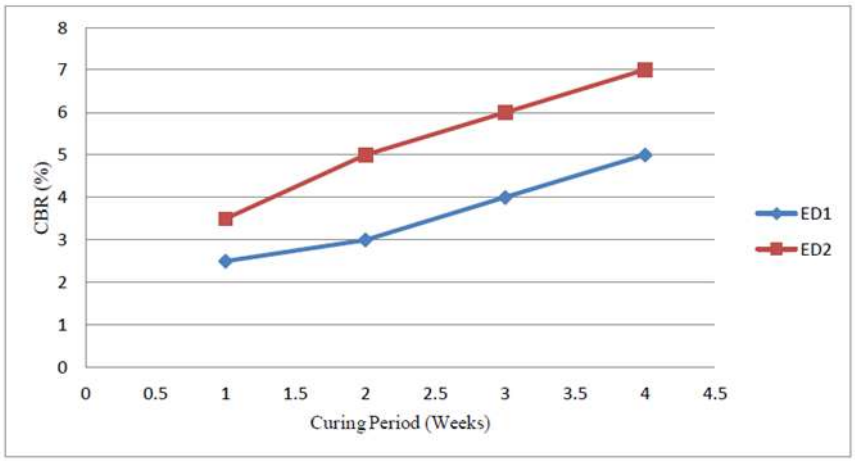


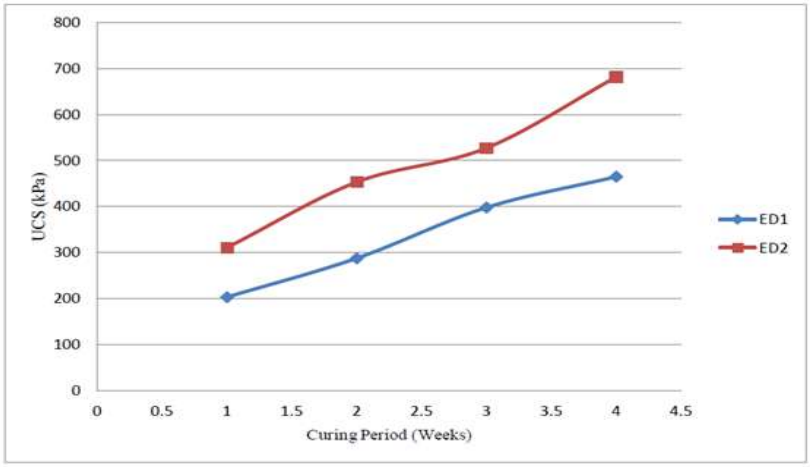
3.4 Un-confined Compressive Strength Tests

Unconfined Compressive Strength of Black soil was evaluated by Stabilization with variable Dosages of Enzyme for one, two, three and four curing weeks. The specimens were prepared and kept in desecrator to retain moisture of the sample so that reaction between soil particle and Ecobond may be continued. The test results have been given in below table 3.4.

Table 3.4: UCS values of Soil Treated with Enzyme

Dosage		Treated Weeks			
		1st	2nd	3rd	4th
1	UCS (kPa)	203	287	397	465
2		310	453	527	681

Graph 3.4: UCS Vs Curing Period for treated soil



3.5 Permeability Tests

Permeability tests were conducted on soil treated with Enzyme at optimum moisture content. Permeability moulds were prepared and kept in airtight bags for testing on its 7, 14, 21 and 28 days curing. Later these moulds were fixed to permeameter and then tested. The test results have been given in below Table 3.5.

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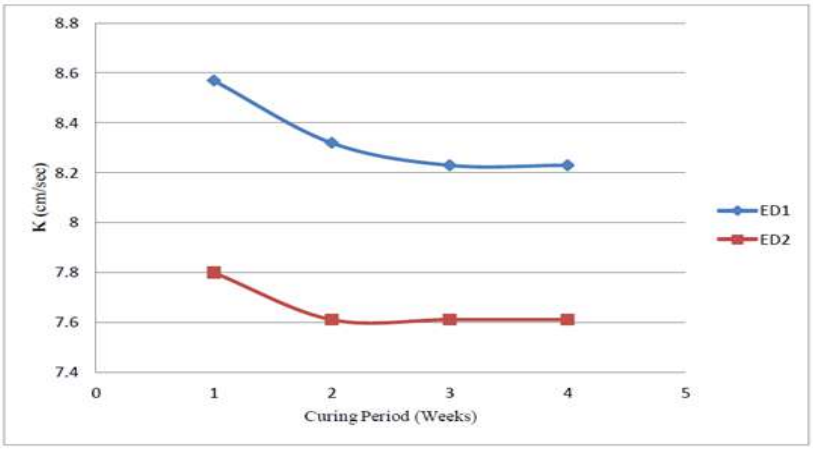
Table 3.5: Coefficient of Permeability of Soil Treated with Enzyme

Dosage	Treated Weeks			
	1st	2nd	3rd	4th
	Coefficient of Permeability (K) cm/s (x10^{-5})			
1	8.57	8.32	8.23	8.23
2	7.80	7.61	7.61	7.61

Graph 3.5: Coefficient of Permeability Vs Curing Period for treated soil



IV. CONCLUSION

Based on the tests conducted the following conclusions have been drawn which are applicable only to materials used and test conditions adapted in the study.

a) Bio-Enzyme Stabilization has shown medium improvement in physical properties of Black soil. This improvement may be due to chemical constituent of the soil which has low reactivity with Bio-Enzyme; therefore it is advisable to first examine the effect of Bio-Enzyme on soil Stabilization in the laboratory beforeactual field trials.

b) The Black Soil properties have been much improved by stabilizing with Enzyme Dosage of 200 ml/ 2 m^3 of Soil.

c) Enzyme is found to be ineffective for improving Consistency Limits.

d) For a higher Dosage of 200 ml/ 2 m^3 of Soil, the CBR value of Black Soil increased by 250 percent after four weeks of curing.

e) Unconfined Compressive Strength of the Soil increased by 380 percent for Dosage of 200ml of 2m^3 soil after four weeks of curing.

f) Permeability decreases by 42 percent for higher Dosage of 200ml of 2m^3 soil after four weeks of curing.

REFERENCES

[1] Bajpai, P. (2014), "Non-conventional Soil Stabilization Techniques The Way Forward to an Aggregate Free Pavement and a Cost Effective Method of Road Construction", International Journal of Scientific and Engineering Research, Vol.05, 1063-1066.

[2] Faisal Ali "Stabilization of Residual Soils Using Liquid Chemical"(2012)Civil Engineering Department, Faculty of Engineering, National Defense University of Malaysia, Kuala Lumpur, Malaysia.

[3] Agarwal, P., and Kaur, S. (2014), "Effect of Bio Enzyme Stabilization on Unconfined Compressive Strength of Expansive.

[4] Shukla, M., Bose, S. & Sikdar, P. 2010."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.

[5] Venkatasubramanian.C & Dhinakaran, G. 2011. "Effect of bio-enzymatic soil stabilization on unconfined compressive strength and California bearing ratio". Journal of Engineering and Applied Sciences: 6(5):295-298.

[6] Christo Ananth,"A Novel NN Output Feedback Control Law For Quad Rotor UAV",International Journal of Advanced Research in Innovative Discoveries in Engineering and Applications[IJARIDEA],Volume 2,Issue 1,February 2017,pp:18-26.

[7] M B Mgangira 2010"evaluation of the effects of enzyme-based liquid chemical stabilizers on sub-grade soils" CSIR, Built Environment,

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ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
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Pretoria.

[8] Marasteanu, M. O., Hozalski, R., Clyne, T. R. & Velasquez, R. 2005. "Preliminary laboratory investigation of enzyme solutions as a soil stabilizer". Minnesota Department of Transportation, Research Services.

[9] Manoj Shukla, Sunil Bose and Sikdar, P.K. (2003): "Bio-Enzyme for stabilization of soil in Road construction a cost effective approach",Presented at the IRC Seminar: Integrated Development of Rural and Arterial Road Networks for Socio-Economic development, New Delhi,December 2003.

[10] Sharma, A., "Laboratory Study to Use of TerraZyme for Soil Stabilisation", Research Report (unpublished) Central Road Research Institute,New Delhi 2001.

[11] U. Ravi Shankar, H. K. Rai, and I. R. Mithanthaya, Bio-Enzyme Stabilized Lateritic Soil as a Highway Material, Journal of the Indian RoadsCongress, Paper No. 553, 2009, 143-151.