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Stabilization of Black Cotton Soil using Terrazyme

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Abstract

Bio-enzyme is a naturally available non toxic and non flammable liquid enzyme formulation which is fermented from vegetable extracts resulting into the higher soil compaction densities and increases the soil stability. The main functions are catalyzing the reactions between the clay and the organic cations and to increase the speed of the cationic exchange process. It can be mixed with water at optimum moisture content and then it is sprayed over compacted soil. In present study, black cotton soil with varying index properties have been tested for stabilization process and the strengths of the stabilized soil were evaluated after the curing period of 0 days, 14 days, 21 days and 28 days for various enzyme quantities 200ml/3m3, 200ml/2.5m3, 200ml/2m3, 200ml/1.5m3. The California Bearing Ratio (CBR) test and Unconfined Compressive strength (UCS) test done for the soil specimen. From the test results, it is clear that bio-enzyme stabilization improves the strength of black cotton soil up to great extent, which indicate the bearing capacity and the resistance to deformation increases in case of stabilized soil. An attempt has been made to study the properties of soil modified with the bio-enzyme, in order to use this technology for cricket pitch as well as low volume roads. Based on laboratory findings, field trials were carried out by using bio-enzyme in some of roads in India. However, in case of leather ball cricket pitch in schools and college, it gets damaged due to weathering action mostly rain and use of ground for multiple games, and improper maintenance of ground. Bio-enzyme Terrazyme stabilized the pitch soil and increases the durability of pitch.

Keywords: *Bio-Enzyme, Terrazyme, Soil Stabilization, Black Cotton Soil, UCS and CBR.*

1. Introduction

In Indian subcontinent, many areas having soils with low strength, high silt content and minimal bearing capacity. In case of such type of soils at the construction site, the best alternate is to modify the soil properties, so it meets the design requirements of pavements. Suitable stabilization technique has to be adopted for a particular situation after considering the soil properties, since the nature and properties of natural soil vary widely [1, 2]. Soil improvement by chemical and mechanical mean is widely used. Recently Bio-Enzymes have emerged as new chemical for stabilization which are based on the organic chemicals and liquid concentrated substances, used to improve the stability of soil sub base of pavement structures. It is convenient to use, safe, effective and improves the road quality [3]. The objectives of stabilization technique

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is to increase the stiffness and strength of the soil, improve workability and constructability of the soil and reduce the plasticity index.

2. Material

The soil used in this study is black cotton soil (dark grey in colour) which is collected from Shankarpur of Nagpur District, Maharashtra and college ground of Government College of Engineering Nagpur. Liquid stabilizer Bio-Enzyme (Terrazyme) is used as admixture to stabilize the investigating soil. The manufacturer's data is available for the product is shown in Table 1.

Table 1. Enzyme Properties

Physical and Chemical Characteristics	
Boiling Point	212º F
Specific Gravity	1.05
Evaporation Rate	Same as water
Solubility in water	Complete
Appearance/ Odor	Brown Liquid, Non-Obnoxious

3. Enzyme Dosage

The enzyme dosage ranges from 200 ml/3.5m^3 to 200 ml/1.5m^3 of soil, and it depends upon soil properties. For expansive clayey soil, the enzyme dosages assumed was 200 ml for bulk volume of 3.5 m^3 to 1.5 m^3 of soil.
Bulk density of black cotton soil = 1.56 gm/cc,
Bulk Density = Weight / Volume
Weight = Bulk Density x Volume

For Dosage 1

200 ml for 3.0 m^3 of soil = 1.57x 3.0 x 1000 = 4710 kg of soil for 1 kg = 0.042 ml of Enzyme

For Dosage 2

200 ml for 2.5 m3 of soil = 1.57 x 2.5x 1000 =3925 kg of soil for 1 kg = 0.051 ml of Enzyme

For Dosage 3

200 ml for 2.0 m3 of soil = 1.57x 2.0 x 1000 = 3150 kg of soil for 1 kg = 0.064 ml of Enzyme

For Dosage 4

200 ml for1.5 m3 of soil = 1.57x 1.5 x 1000 = 2355 kg of soil for 1 kg = 0.085 ml of Enzyme.

Table 2. Enzyme Dosage

Dosage	**200ml/m^3 of soil**	**ml/kg of soil**
1	3.0	0.042
2	2.5	0.051
3	2.0	0.064
4	1.5	0.085

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4. Basic Properties of Enzyme Dosage

Table 3. Properties of black cotton soil

Sl. No	Property	Value	IS Codes
1	Specific Gravity	2.48	IS 2720 (part III)
2	Atterberg limits Liquid limit (%) Plastic limit (%) Plasticity index Shrinkage limit (%)	 61.40 34.00 27.40 16.60	IS 2720 (part V)
3	Grain size distribution a) Gravel (%) b) Coarse Sand (%) c) Fine sand (%) d) Silt & Clay (%)	 0.00 10.17 20.87 68.70	IS 2720 (part IV)
4	USCS Soil Classification	CH	
5	Free Swell Index %	72.80	IS 2720 (part XL)
6	Engineering Properties Light Compaction 1) maximum dry density, (kN/m3) 2) Optimum Moisture Content %	 14.80 23.00	IS 2720 (part VII) IS 2720 (part II)
7	CBR Value (%) IS Standard Compaction a) Un-soaked condition b) Soaked condition	 2.86 1.19	IS 2720 (part XVI)
8	Swelling Pressure in kN/m2	48.00	IS 2720(part XLI)
9	Unconfined compression test in kg/cm2	3.53	IS 2720 (part X)
10	Co-efficient of Permeability	$1.5x10^{-8}$in (cm/sec)	IS 2720 (part XVII)

5. Atterberg Limits

The enzyme treated soil sample's consistency limits were tested immediately after the mixing. The mix becomes stiffer after few weeks of curing. The effect of Terrazyme at different dosage on index properties of black cotton soil have been presented in Table 4.

Table 4. Stabilized black cotton soil consistency limits

Dosage number	Enzyme dosage	Black Cotton soil		
		Liquid limit (%)	Plastic limit (%)	Plasticity index
0	Un treated	61.40	34.00	27.40
1	200ml/3m^3	60.22	33.50	26.72
2	200ml/2.5m^3	59.00	32.79	26.21
3	200ml/2m^3	57.75	32.23	25.52
4	200ml/1.5m^3	56.49	31.70	24.79

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6. Compaction Test

For the black cotton soil having different doses of Terrazyme, standard proctor's test was conducted. Test results are presented in Table 5.

Table 5. MDD and OMC of stabilized BC soil

Dosage No.	Enzyme Dosages	Standard Compaction (Light Compaction)	
		OMC (%)	MDD (gm/cm^3)
0	Untreated	23.00	1.486
1	200ml/3m^3	22.40	1.521
2	200ml/2.5m^3	22.10	1.564
3	200ml/2m^3	21.00	1.590
4	200ml/1.5m^3	20.4	1.633

The increase in MDD with variable doses of Terrazyme is uniform till the final dosage 200ml/1.5m^3. This defluxion happens due to the formation of transitional compounds that have higher density in the range of 3rd -4th enzyme dosage.

7. Unconfined Compression Strength (UCS) Test

UCS of black cotton soil was evaluated by stabilization with variable dosages of enzyme for 0, 7, 14, 21 and 28 days of curing. The specimens were kept and prepared in desiccators to retain the moisture of the sample so that reaction between soil particle and enzyme may be continued. Number of samples were tested with different dosage of enzyme i.e. 200 ml for 3, 2.5, 2 and 1.5 m3 of soil. The test results are summarized in Table 6.

Table 6. Unconfined Compressive Strength value of black cotton soil with varying enzyme dosage & curing time

Dosage No.	Dosages	UCS of BC soil in (KPa) for period of treatment				
		0 day curing	7 days curing	14 days curing	21 days curing	28 days curing
0	Untreated	3.53	3.78	4.05	4.21	4.63
1	200ml/3m^3	4.00	5.10	5.75	6.17	6.92
2	200ml/2.5m^3	4.64	5.55	6.37	7.10	7.74
3	200ml/2m^3	5.20	6.41	7.00	7.82	8.63
4	200ml/1.5m^3	5.57	6.64	7.27	7.95	8.86

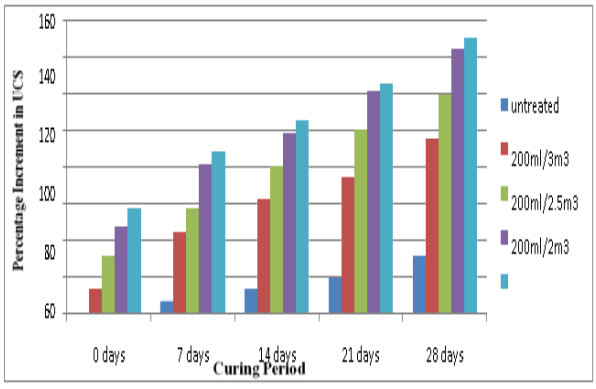

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Figure 1. Percentage Increment in UCS Test

8. California Bearing Ratio (CBR) Test

The BC soil was treated with 4 doses of enzyme at optimum moisture content 23%. The CBR moulds were prepared with different doses by standard proctor test and kept by covering plastic bags for testing on different days. Further for soaking conditions, moulds were kept in water condition for 4 days and then tested for CBR. The soaked CBR values of black cotton soil with different enzyme dosages of Terrazyme in various days of curing are given in Table 7.

Table 7. California Bearing Ratio test of BC soil with varying enzyme dosage and curing time

Dosage No.	Soil Enzyme Dosage					
		0 day	7th days	14th days	21th days	28th days
0	Untreated					
1	200m//3m^3	1.20	1.32	2.40	3.70	5.21
2	200ml/2.5m^3	1.22	1.67	2.59	3.83	5.40
3	200ml/2m^3	1.23	1.93	2.91	3.97	5.63
4	200ml/1.5m^3	1.25	2.00	3.12	4.21	5.80

9. Conclusion

Performance of soil stabilized with Bio-Enzyme has been investigated in this work. Based on the tests conducted in the laboratory, the following conclusions were drawn:

1) The clay amount plays a major role in the variation of consistency limits. It is found that liquid limit decreases from 61.40 % to 56.49 %, while the plastic limit reduces from 34.00% to 31.70% at the dosage no.4.
2) There is marginal changes for MDD of enzyme treated soil which is from 1.486 gm/cm^3 to1.633gm/cm^3 whereas decrease in OMC is observed to be 23.00 % to 20.40 %. The effective cation exchange process which generally takes longer period in the absence of such stabilizers decreases the OMC.
3) The UCS value increases from 3.53 kN/m^2 to 8.86 kN/m^2 when compared to the original soil after 4 weeks of curing period. This is due to the reaction of enzyme with clay resulting in cementation effect. The reaction time is significant as the strength after 4 weeks (150.99% increase from original soil) is greater than that at 1week (88.10% from the original soil). It is observed that the treated soaked California Bearing Ratio values are increased as the curing period increase which is because soil treated with enzyme renders improved density values by reducing the void ratios. Initially for the local soil the soaked CBR value was 1.19 % but with stabilization after 4 weeks of curing the soaked California Bearing Ratio value was 5.80% which shows the increase of 387 % from the original soil.
4) The leather ball cricket pitch in schools and college, it gets damaged due to weathering action mostly rain and use of ground for multiple games, and improper maintenance of ground. Bio-enzyme Terrazyme stabilized the pitch soil and increases the durability of pitch.

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