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Strength Properties of Bioenzyme Treated Black Cotton Soil

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Abstract

Bioenzyme (Terrazyme) is a natural, non-toxic, non-corrosive and non-flammable liquid enzyme formulation fermented from vegetable extracts that improves the engineering property of soil and increases the stability by accelerating the reactions between the clay and the organic cations and accelerates the cationic exchange process to reduce the diffused double layer thickness.

In the present study, an effort was made to study the effects of varying dosages of Terrazyme (TZ) on strength properties of Black Cotton Soil (BCS) for different cuing periods. Tests were carried out to determine the Atterbergs limits, Unconfined Compressive Strength (UCS) and California Bearing Ratio (CBR) of the soil specimens with and without Terrazyme subjecting to desiccator curing. The experimental results indicate that the Bioenzyme stabilizer used in the present investigation is effective in improving the strength properties of Black Cotton Soil and can be used in place of conventional soil stabilizers.

Keywords: Bioenzyme, Black Cotton Soil (BCS), Stabilizer, Strength

INTRODUCTION

Soil stabilization is the process of improving the geotechnical properties of soil and thus making it more stable. It is a very useful technique for major civil engineering works. To utilize the full advantage of the technique, quality control must be adequate. Soils may be stabilized to prevent erosion and dust generation Conventional soil stabilizers like Cement, lime, bitumen and chemical admixtures are effectively used to find the effects on strength, settlement and swell shrink nature of soils. Very little work have been conducted and published on utilizing Bioenzymes for stabilizing soils. Conventional soil stabilizers like Cement, lime and bitumen are expensive and create negative impact on environment.

Greeshma Nizy Eujine , S. Chandrakaran and N. Sankar (2017) studied the effect of lime and Terrazyme on different types of soft soil.. The test parameter considered was California bearing ratios (CBRs). The test results indicate that that the addition of bio-enzyme with lime accelerated the strength improvement and resulted in a stronger soil matrix. The authors concluded that the pavement designer can adopt this new technology to reduce the pavement thickness.

Joydeep Sen and Jitendra Prasad Singh (2015) made an attempt to study the the effect of varying dosage of Terrazyme at different curing periods. The tests which were California Bearing Ratio (CBR) test and Unconfined Compressive strength (UCS) test of the soil specimen were carried out in the laboratory. The test results reveals that the strength of bio-enzyme treated black cotton soil is significantly increased and enzymes are effective for stabilization of expansive soils.

Puneet Agarwal and Suneet Kaur (2014) conducted experimental work on Black Cotton Soil using Terrazyme as a stabilizing agent. Unconfined Compressive strength of the Black Cotton soil with and without Terrazyme was determined for different curing periods The test results indicates that Terrazyme treated Black cotton soil shows significant improvement in strength for longer period.

Sureka Nagesh and Gangadhara. S (2010) report the results of experiments conducted on an expansive soil treated with an organic, non-toxic, eco-friendly bio-enzyme stabilizer in order to assess its suitability in reducing the swelling in expansive soil. The experimental results indicate that the bio enzyme stabilizer used in the present investigation is effective and the swelling of an expansive soil reduces on wet side of OMC.

Ramesh H N and Sagar S.R (2015) studied the effect of curing on the strength properties of Terrazyme treated black cotton soil and red earth for the curing periods from 7days to 60days. The test results indicate that air-dry curing is best suited for Terrazyme stabilization of expansive and non-expansive soils

An attempt has been made in the present study to improve the strength properties of expansive soil using the nonconventional soil stabilization technique through the application of Terrazyme.

MATERIALS AND METHODOLOGY

For the present study the Black Cotton soil was obtained from Bagalkot. The soil was obtained by excavating 2 m below the natural ground surface. The soil was air dried and pulverized in a ball mill. The pulverized soil passing through 425µ IS

sieve has been used for the present work. All geotechnical tests were carried out according to procedures specified in respective Indian standard codes. The test procedures for various experiments conducted in the present investigation are briefly explained in sub sections. The Engineering properties of Expansive soil are determined as per Indian Standards and presented in the Table 1. The bio-enzyme used to stabilize the soil sample was obtained from the Avijeet Agencies, Chennai

Table 1: Geotechnical properties of Expansive soil used in present study

Sl.no	Properties		Value
01	Grain Size Distribution	Fine sand size (%)	6
		Silt size (%)	31
		Clay size (%)	63
02	Specific Gravity of soil solids		2.70
03	Liquid limit (%)		81
04	Plastic limit (%)		36
05	Shrinkage limit (%)		08
06	Plasticity Index (%)		45
07	Optimum Moisture Content (%)		30
08	Maximum Dry Unit Weight (kg/m^3)		1350
09	Unconfined Compressive Strength (N/mm^2)		159
10	Unsoaked California Bearing Ratio (%)		3

RESULTS AND DISCUSSIONS

This section summarizes the experimental results of the Atterberg limits tests, compaction tests, unconfined compressive strength tests for different dosages of Terrazyme treated black cotton soil. The CBR test is conducted for the soils treated with optimized dosage of Terrazyme.

Atterberg Limits

Black cotton soils treated with Terrazyme were cured in desiccators curing. Later the specimens were subjected to Consistency limits such as liquid limit, plastic limit and shrinkage limits. Test is conduct on immediately mixed and 7 days cured samples. The results of the Atterberg Limits tests have been given in table 2.

Table 2: Consistency limits of Expansive Soil treated with different dosages Terrazyme for different curing periods

Terrazyme dosage	Liquid limit (%)		Plastic Limit (%)		Shrinkage limit (%)	
	Curing Periods		Curing Periods		Curing Periods	
	Immediate	7days	Immediate	7 days	Immediate	7 days
Expansive soil alone	81	81	36	36	08	08
TZ 1 (200ML / 2m^3 of Soil)	81	80	36	34	08	09
TZ 2 (200ML / 1.5m^3 of Soil)	81	79	36	33	08	10
TZ 3 (200ML / 1m^3 of Soil)	81	76	36	31	08	12
TZ 4(200ML / 0.5 m^3 of Soil)	81	76	36	31	08	12

The liquid limit of black cotton soil decreases with curing periods of 7 days for all the dosages of Terrazyme. The plastic limit shows with increase in dosage of Terrazyme, the plastic limit of Soil has no changes for immediately tested samples and that for 7 days cured sample the plastic limit has been decreased from 36% to 31%. This shows that plastic limit decreases slightly with increase in Terrazyme content. Decrease in plastic limit is due to depression of diffused double layer thickness associated with clay particle. The shrinkage limit of black cotton soil alone is found to be 8%. From the results of shrinkage limit test, it can be shown that increase in the dosage of Terrazyme increases the shrinkage limit to an appreciable value for a period of 7 day curing. This may be due to the aggregation of particle caused by the increase in binding of the soil particles due to treatment from Terrazyme and also with the curing period. Fig. 1 and Fig. 2 show the variation of Atterbergs Limits for Immediate and 7 days curing testing respectively.

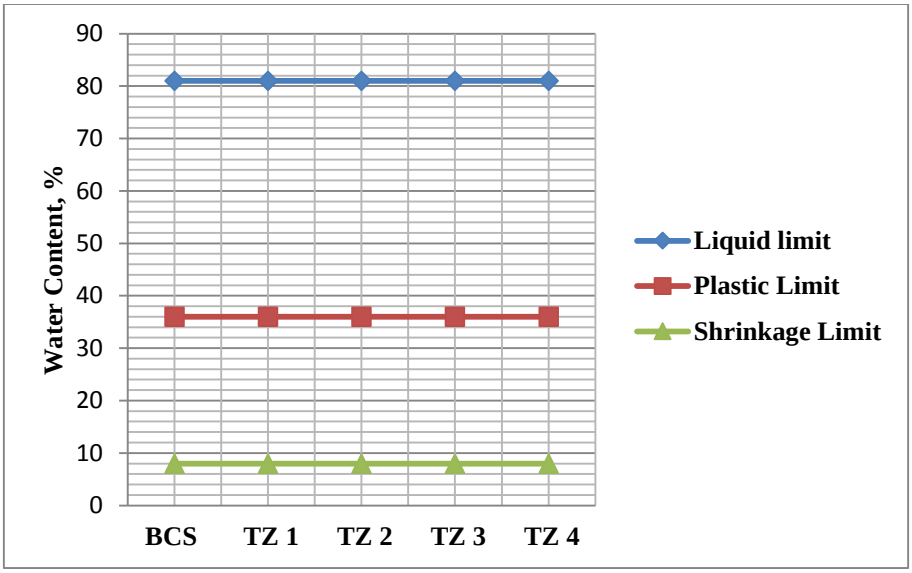

Figure1: Variation of Atterbergs limits for Immediate Testing

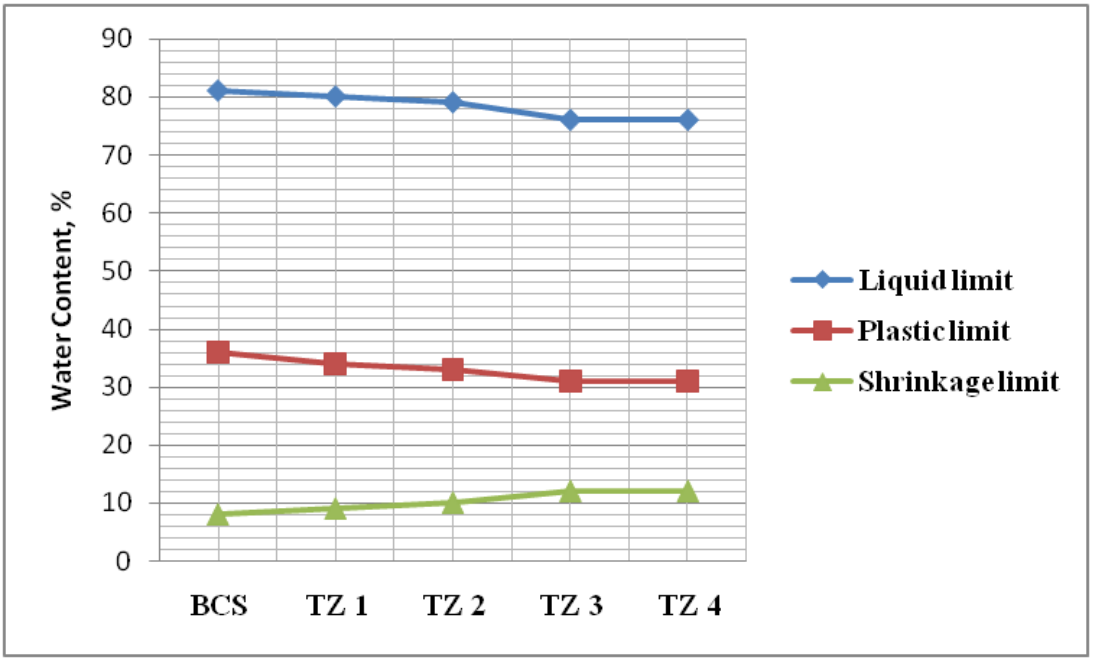

Figure 2: Variation of Atterbergs limits after 7 days of testing

Compaction Characteristics

Compaction is the process of increasing the density of the soil by packing the particles closer together with reduction in the volume of air. Densification of soil improves their engineering properties. The tests have been carried out by adding various dosages of Terrazyme to the water to be mixed with the soil during compaction depending on the dosage calculations. The compaction test was conducted immediately after mixing the soil and water to avoid time lag for the reaction to occur. The maximum dry density and optimum moisture content of black cotton soil is 13.50 kN/m3 and 30%. On addition of various dosages of Terrazyme, the maximum dry density shows only little variation, Terrazyme requires some amount of time to start acting on the soil particles. Fig. 3 shows the compaction characteristics of BCS treated with different dosages of Terrazyme.

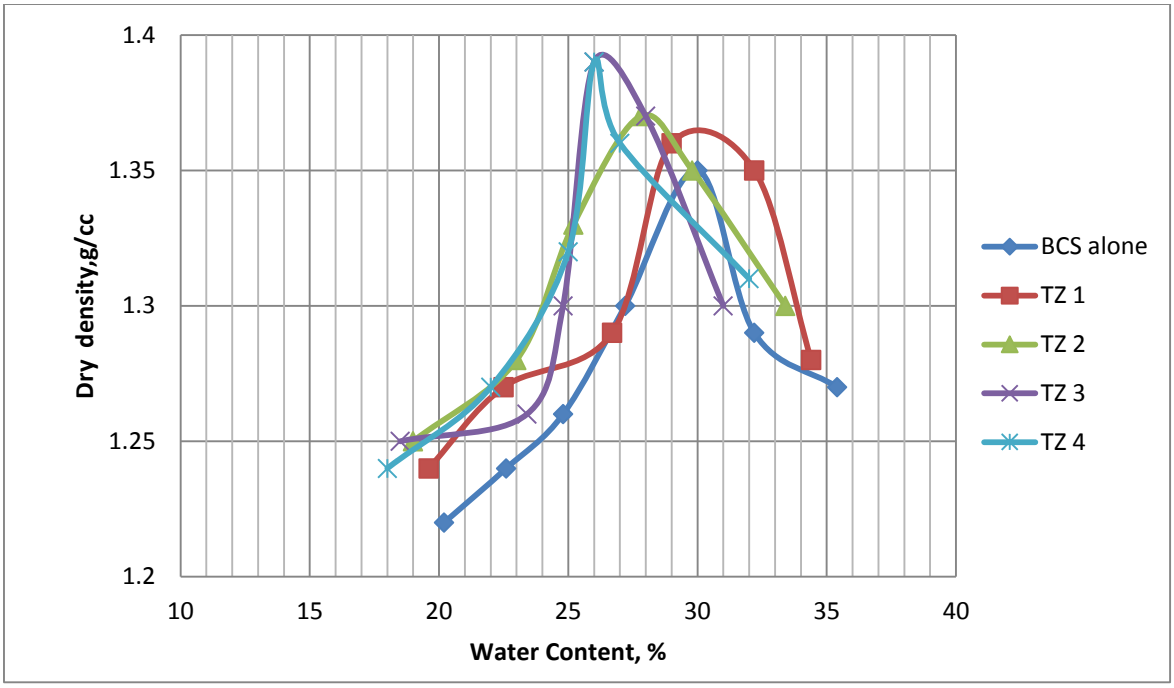

Figure 3: Compaction Characteristics of BCS treated with different dosages of Terrazyme

Unconfined Compressive Strength Test

Unconfined compressive strength of black cotton soil was evaluated by stabilization with variable dosages of Terrazyme and subjected to desiccator curing conditions up to 7 days of curing.

The strength variations of Terrazyme treated Black cotton soil have been explained based on the unconfined compressive strength values. As seen from table 3 and figure 4, the strength of black cotton soil alone without curing is 159kPa. On addition of Terrazyme, the strength has increased up to 322 kPa with desiccator curing of test specimens. Specimens treated with dosage 3 (TZ 3) has been considered as the optimum dosage based on Atterbergs limits test and Unconfined Compression Test (UCS).

Table 3: Unconfined Compressive Strength of Black Cotton Soil treated with different dosages of Terrazyme

Mixtures	**Compressive Strength in Kpa**	
Curing period in days	0 days	7 days
BC Soil alone	159	159
TZ 1	163	193
TZ 2	176	229
TZ 3	184	318
TZ 4	188	322

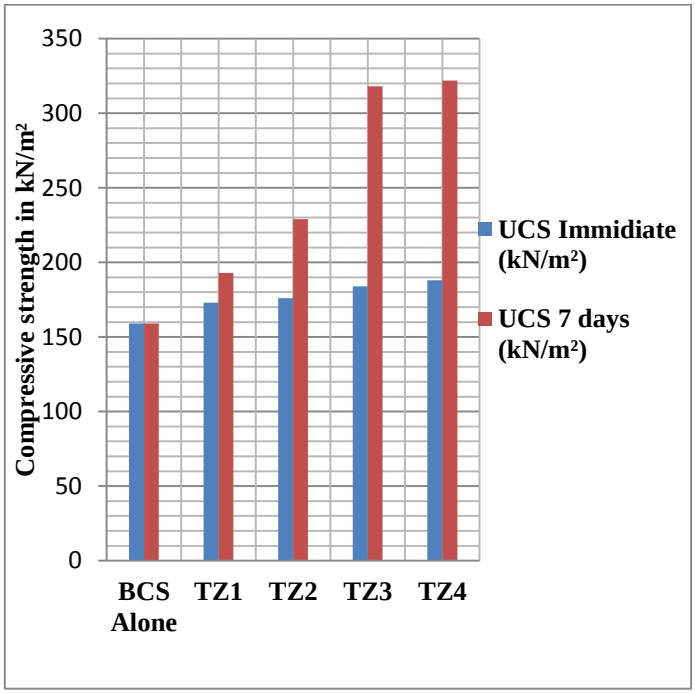

Figure 4: Variation of Compressive Strength for different dosage of Terrazyme for during curing periods

Unsoaked CBR Tests

The tests were conducted on the black cotton soil alone and treated with Terrazyme of dosage3 (TZ 3) for Unsoaked CBR value. The unsoaked CBR value of black cotton soil alone was 3%. After treating the soil with optimum dosage of Terrazyme i.e. TZ 3, the specimens were cured for 7days. On 7th day of curing the treated specimen had unsoaked CBR value 8 % for

desiccator curing. Nearly 170% increment in unsoaked CBR value is achieved in desiccator curing.

Table 4: CBR (%) of Black Cotton Soil treated with optimum dosages of Terrazyme (TZ 3)

Combination	**CBR (%)**	
Curing Period in days	0	7
BC Soil alone	3	-
BCS + TZ3 (200ML/1.0m^3 of Soil)	5	8

Conclusions

1) No significant changes in the atterbergs limits for different dosages of Terrazyme treated soils for immediate testing.
2) Addition of various dosages of Terrazyme decreases the liquid limit of black cotton soil with the curing period. This is because of molecular rearrangement in the micro-structure level of the soil particles and due to reduction in the diffused double layer thickness of the soils.
3) Addition of various dosages of Terrazyme decreases the plastic limit of black cotton soil. This may be due to attainment of hydrophobic nature of soil particles and the reduction in the diffused double layer of the soils. The shrinkage limit of the black cotton soil increased significantly with curing period.
4) Immediate compaction testing of Terrazyme treated soils shows no significant changes in the compaction behaviour. Terrazyme requires curing time to initiate the treatment process as it is a micro-biological process.
5) Treating black cotton soil with Terrazyme, the strength increases for all dosages of Terrazyme. The rate of increment in strength for dosage 3 is higher compared to the other dosages. Hence, dosage 3 of Terrazyme is considered as optimum dosage for black cotton soil.
6) Treating black cotton soil with optimum dosage of Terrazyme (TZ 3) resulted in increase of unsoaked CBR value for desiccator curing.

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