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## **Influence of TerraZyme on Geotechnical Properties of Clayey Soils**

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**Abstract.** Expansive soil swells and shrinks with regular wetness variation make structures founded on it unhinged and in practical cause huge economic loss in transportation division. The most important intend of stabilization is cost decline and to efficiently use the nearby available material. The stabilization of soil by bioenzyme is an innovative method which is attractive worldwide. In present study, an attempt is made to study the geotechnical properties of soil stabilized with the TerraZyme. Laboratory experiments were carried out blending TerraZyme with red soil/black cotton soil in different dosages and the effect on Atterberg's limits, modified Standard Proctor tests, Soaked and Unsoaked California Bearing Ratio CBR test were studied. The experimental values proved that there is an increase in strength parameters for the both soils stabilized with TerraZyme.

**Keywords:** Black Cotton Soil, Red Soil, TerraZyme, Compaction, CBR

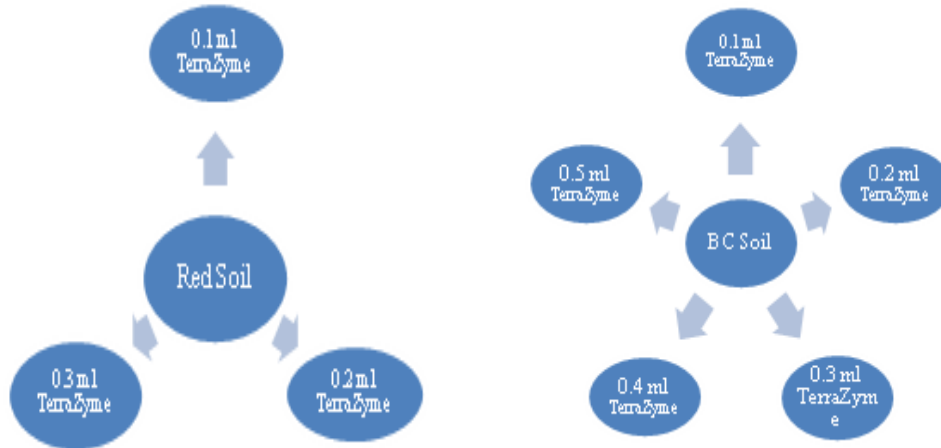
### **1 Introduction**

The improvement of soil nature is important to build the soil safe in performance the load of structures. Ground improvement technique which consists of stabilization of soil by way of mechanical and chemical methods or together. The stabilization of soil with bioenzyme is a world-shattering practice which is popular worldwide. The main feature of TerraZyme is the remarkable cost saving aspect. TerraZyme saves cost from 15% to 40% in comparison to the conventional system of road construction. Laboratory investigations are carried out blending TerraZyme with soil in different dosages and conducted a series of experiments on locally available clayey soil as well as clayey soil in order to know the improvement of strength properties of TerraZyme stabilized the soil. Results show that the TerraZyme can successfully be used to stabilize the soil and significant improvement was found in both Soaked CBR and Unconfined Compressive Strength after 4weeks of curing [1]. Black Cotton Soil mix with different dosages of TerraZyme and carried out laboratory experimentation at different cuing periods. From the experimental results indicates that, the addition of various dosages of TerraZyme decreases the liquid limit due to molecular rearrangement in the micro-structure level of the soil particles and due to reduction in the diffused double layer thickness of the soils, decreases the plastic limit of black cotton soil attained due to attainment of hydrophobic nature of soil particles and the reduction in the dif-fused double layer of the soils. There are no significant changes in the compaction

behaviour. And at the rate of increment in strength for dosage 3 is highly compared to the other dosages resulted in increase of unsoaked CBR value for desiccator curing [2]. Land improvement using bioenzyme with different doses of TerraZyme was studied, and the results shows a significant increase in the CBR value, optimal improvement in the stability limits, dry density and the best result of CBR value was the two-week curing period at 900ml / m<sup>3</sup> dose and the percentage increase of 131.49% compared to the native soil sample without TerraZyme [3]. The improvements in geotechnical properties of Black cotton soils and red soils treated with Terra-Zyme stabilizer at different curing periods and different mix proportions studied by conduct experiments and best result for LL values was observed with the second dosage 200ml per. 0.75 m<sup>3</sup>, UCS values increased around 94.86%, 114.69%, 150.28%, and 63.34% till twenty-one days, [4]. The effect of curing on the strength properties of TerraZyme treated black cotton soil and red earth for the curing periods from 7days to 60 days and concludes that enormous increment in strength compared to laboratory conditions of desiccator curing and results indicate that air-dry curing is best suited for TerraZyme stabilization of expansive and non-expansive soils and in order to use this technology for low cost soil stabilization techniques, [5]. Bioenzymes results in higher compressive strength and increased hardness provides flexibility and durability to the pavement and also reduces the formation of crack, reduce swelling and shrinkage properties of highly expansive clays of stabilized soil. The use of bioenzyme in pavement construction is proven to be very economical as compared to other traditional soil stabilization methods. The cost of project construction can be reduced considerably with the use of bioenzyme, [6]. In this research work, an attempt has been made to work out the Index and engineering properties of black cotton soil /red soil blend through disparate ml of TerraZyme. In this study, the major properties are Atterberg's Limits, Compaction and CBR tests were carried out for all samples and when compared with natural soil samples. From the examination outcome there is an improvement in geotechnical properties of stabilized black cotton soil/red soil blend with chemical admixture.

## 2 Study Design

The present study has planned in three stages. In the first stage, it is proposed to carryout individual geotechnical properties in laboratory of the materials used during the study. In the second phase, stabilization method tried in the laboratory carried out blending with different dosages of TerraZyme to calculate the optimum percentage as presented in Fig. 1. From the laboratory experimentation and comparison will be made with a view to know the improvement in geotechnical properties.



**Fig. 1.** Flow Chart Showing Different ml of TerraZyme Blend with Red Soil and Black Cotton Soil

### 3 Materials Used

Details of various materials used throughout the laboratory testing are presented in the succeeding section. In the present study; locally available red soil and black cotton soil were used.

**3.1 Black cotton soil (BC):** The soil used was a typical black cotton soil procured from ‘Amalapuram’, East Godavari District, Andhra Pradesh State, India. All the tests carried on the soil are as per IS specifications. The geotechnical properties of soil are presented in the Table.1

**3.2 Red soil (RS):** The soil used in this study was a typical Red soil which was collected from local village. This soil is classified as per IS classification as inorganic clay of low compressibility (CL). The geotechnical properties of soil are presented in the Table.1

**3.3 TerraZyme (TZ):** It is a natural, non-toxic, non-corrosive and non-inflammable liquid, produced by formulating vegetable and fruit extracts. TerraZyme used in this study was obtained from Chennai, India. TerraZyme is specially formulated to modify the engineering properties of the soil. It requires dilution in water before application. The physical properties of TerraZyme presented in the Table.1

**Table 1.** Geotechnical properties of clayey soil

S.No	Laboratory Test	Black Cotton Soil	Red Soil	Relevant IS Codes
1	Differential Free Swell(DFS)	142%	42%	IS 2720 Part XI
	Atterberg's limits			
2	Liquid Limit(W <sub>L</sub> )	87.12%,	32.64%	IS 2720 Part V
	Plastic Limit(W <sub>P</sub> )	33.43 %	20.84 %	IS 2720 Part V
	Plasticity Index(PI)	53.69%	11.8%	IS 2720 Part V
3	Specific Gravity(G)	2.67	2.34	IS 2720 Part III
Grain Size Analysis				
3	Coefficient of Uniformity(Cu)	6.7	4	IS 2720 Part IV
	Coefficient of Curvature(Cc)	2.01	1.1	IS 2720 Part IV
Compaction Parameters (Modified Proctor Test)				
4	Optimum Moisture Content(OMC)	26.73 %,	21.3 %	IS 2720 Part VIII
	Maximum Dry Density(MDD)	15.12 kN/m <sup>3</sup>	16 kN/m <sup>3</sup>	IS 2720 Part VIII
5	California Bearing Ratio (Soaked) (CBR)	1.35%	3.14%	IS 2720 Part XVI
6	Unconfined Compressive Strength(UCS)	40.74 kN/m <sup>2</sup>	210 kN/m <sup>2</sup>	IS 2720 Part X

**Table 2.** Properties of TerraZyme

<i>Identity</i>	<i>TerraZyme</i>
Hazardous Components	None
Boiling Point	212°F
Specific Gravity	1.05
Melting Point	Liquid
Evaporation Rate	Same as water
Solubility in Water	Complete
Appearance/Odor	Brown liquid, Non-obnoxious
Unstable/Stable	Stable
Conditions Avoid	> 45°C ; pH below 3.5, above 9.5
Incompatibility	Caustics, Strong bases
Health Hazards (Acute and Chronic)	None
Disposal Method	Flush into any sewage system
Storing	Store at temperatures below 45°C
Working	Normal good practices

## **4 Laboratory Experimentation**

Various tests were carried out in the laboratory for finding the index and other important properties of the soils used during the study. Atterberg's Limits, Compaction and CBR tests were conducted by mixing different ml of TerraZyme with a view to find the optimum quantities and its effect on strength properties of different clayey soils and the details of these test results presented in the following sections

**4.1 Index properties:** Regular procedures recommended in the relevant I.S. Codes of practice [IS:2720 (Part-5)-1985; IS:2720(Part-6)-1972], were followed while finding the Index properties viz. Liquid Limit and Plastic Limit of the samples tried in this study.

**4.2 Compaction properties:** Optimum Moisture Content and Maximum Dry Density of Black cotton soil/Red soil blend with different ml of TerraZyme conducted as per IS heavy compaction test IS: 2720 (Part VIII) -1983.

**4.3 California Bearing Ratio (CBR) test:** CBR test was carried out on prepared soil samples of untreated and treated black cotton soil/red soil with various ml of TerraZyme under unsoaked/soaked conditions as per IS: 2720 Part XVI-1987 recommendations.

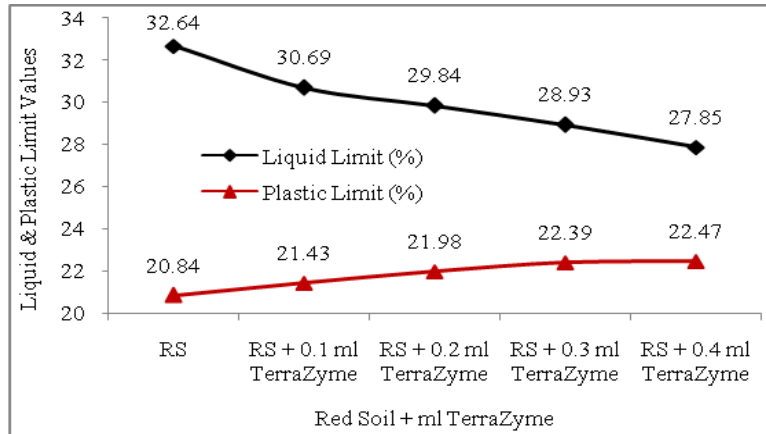
## **5 Results and Discussions**

Throughout the study they conducted laboratory tests for finding index and other significant geotechnical properties of the materials,. Atterberg's Limits, Compaction and unsoaked/soaked CBR tests were conducted by adding up different ml of TerraZyme mixed with black cotton soil/red soil for finding optimum percentages and its outcome on geotechnical properties.

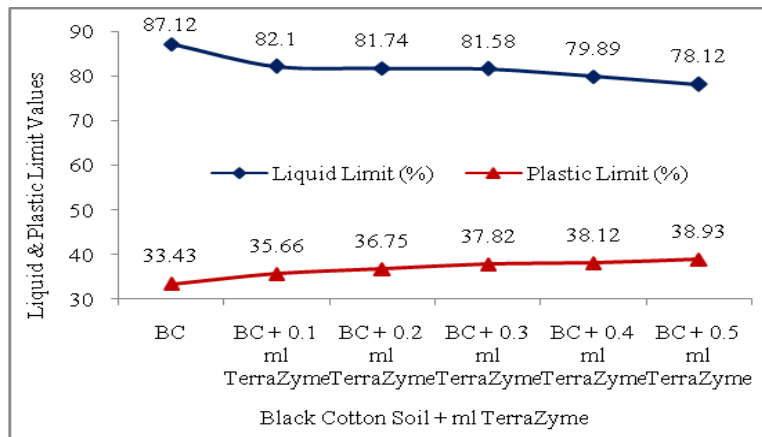
**5.1 Variation of liquid & plastic limit properties:** The liquid limit values are decreasing for red soil blending of various ml of TerraZyme from 32.64% to 27.85% and plastic limit values are increasing from 20.84% to 22.47% respectively when 0 ml to 0.4 ml of TerraZyme mixed with red soil as shown in the Fig. 2. The liquid limit values are decreasing from 87.12% to 78.12 % and the plastic limit values are increasing from 33.43% to 38.39% for black cotton soil, when different ml of TerraZyme from 0 ml to 0.5 ml respectively presented in the Fig. 3. The decrease in liquid limit is due to the effective cation exchange process which generally takes a longer period in the absence of such stabilizers and is due to the reaction of the enzyme with clay which results in cementation effect.

**5.2 Effect on compaction parameters:** The maximum dry density of red soil was increased from 16 kN/m<sup>3</sup> to 16.75 kN/m<sup>3</sup> and optimum moisture content decreasing from 21.3% to 20.01% respectively when 0 ml to 0.3 ml of TerraZyme respectively as

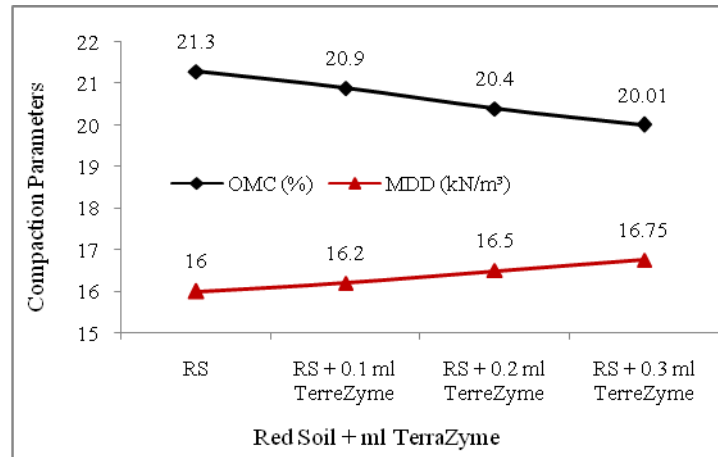
presented in the Fig. 4. For black cotton soil the maximum dry density values are increased from 15.12 kN/m<sup>3</sup> to 16.73 kN/m<sup>3</sup> upto 0.4ml TerraZyme and further addition it starts decreasing and optimum moisture content values are decreased continuously when different ml of TerraZyme adding respectively as shown in the Fig.5.



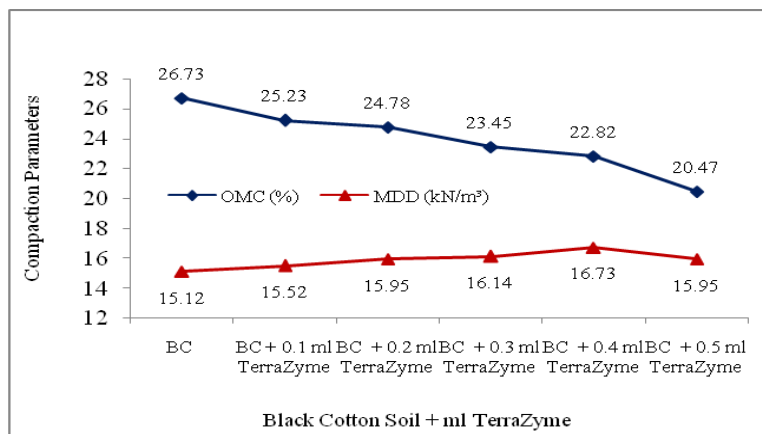
**Fig.2.** Variation in Liquid and Plastic Limit Values of Red Soil Treated with Different ml of TerraZyme.



**Fig.3.** Variation in Liquid and Plastic Limit Values of Black Cotton Soil Treated with Different ml of TerraZyme.



**Fig.4.** Variation in Compaction Parameters of Red Soil Treated with Different ml of TerraZyme.



**Fig.5.** Variation in Compaction Parameters of Black Cotton Soil Treated with Different ml of TerraZyme.

**5.3 Effect on CBR:** Addition of different ml of TerraZyme to red soil, the unsoaked and soaked CBR values are increased from 4.46% to 9.32%; 3.14% to 7.67% upto 0.3 ml of TerraZyme and further addition it decreases as represented in the Fig. 6. For black cotton soil, the unsoaked and soaked CBR values increasing from 2.78 % to 8.19%; 1.74 % to 7.47 % upto the addition of 0.4 ml of TerraZyme and further addition it decreases as shown in the Fig.7 respectively. It is observed that the soaked CBR values are increased as the curing period's increase, which is because of soil treated with enzyme renders improved density values by reducing the void ratios.

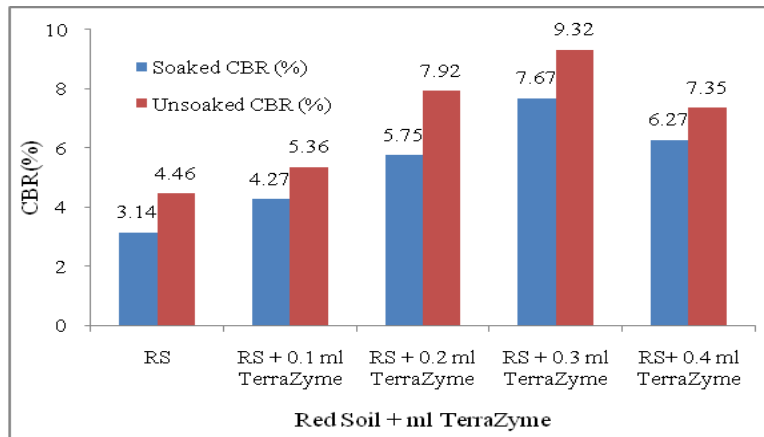


Fig.6. Variation in CBR Values of Red Treated with Different ml of TerraZyme.

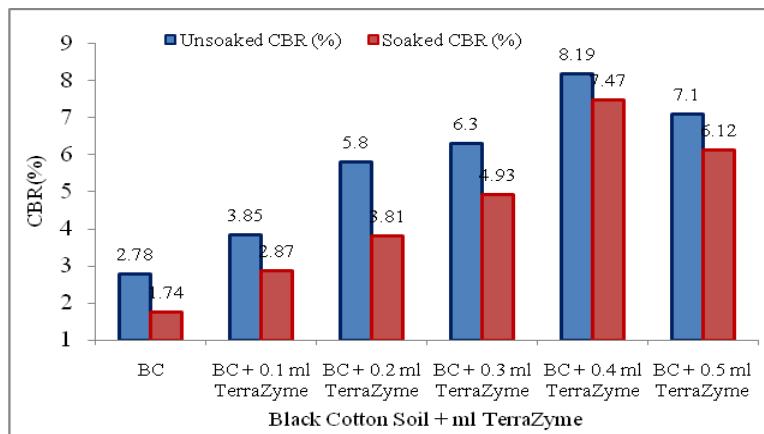


Fig.7. Variation in CBR Values of Black Cotton Soil Treated with Different ml of TerraZyme.

## 6 Conclusions

The Performance of TerraZyme stabilized soils has been investigated in this work. The following conclusions were made based on the experiments carried out in this investigation.

TerraZyme stabilization has shown excellent improvements in engineering properties of both black cotton soil and red soil.



Less significant changes in the Atterberg's limits for different dosages of TerraZyme treated red soil /black cotton soils. It decreases the liquid limit as TerraZyme content increases and also increases the plastic limit.

TerraZyme reduce the compaction exertion and improves soil workability throughout the sample preparation and MDD increases and OMC decreases with addition of TerraZyme.

With increase in dosage of TerraZyme the both soils attains more strength with minimum compaction effort such that the CBR value increases.

The optimum dosages of TerraZyme for Red Soil and Black Cotton Soil are 0.3ml and 0.4 ml respectively and further adding the dosage of TerraZyme, the CBR values do not prove any significant change.

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