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Effect of Bio enzyme – TerraZyme on Compaction, Consistency Limits and Strength Characteristics of Expansive Soil

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Abstract – *Expansive soils are one of the most problematic materials that are widely encountered in significant land areas in several parts of the world. The Surat City situated in South Gujarat region in India have majority of top soil as black cotton soil. The black cotton soil has characteristics of shrinking on drying and heaving on wetting. Cement, lime and bitumen are conventional soil stabilizers, whose effectiveness have been widely reported in the literature. They are however, expensive and some have been reported as not being environment-friendly. In recent year soil Stabilization with an organic bio-enzyme is new technology. Bio-enzyme is a natural, non-toxic, non-flammable, non-corrosive liquid enzyme formulation fermented from vegetable extracts that improves the engineering qualities of soil, reduce compaction efforts, increases the density and increases stability. Very little research has been done for the laboratory studies on behavior of enzyme treated soils. In the present study, an attempt has been made to study the effect of Terrazyme on the properties of expansive soil on consistency limits, compaction characteristics and also Shear Strength of soil with four different dosage of 200ml/1.5m³, 200ml/1.0m³, 200ml/0.5m³, 200ml/0.25m³ with Curing periods of 7,14,21 days. CBR for the dosage 200ml/0.25 m³ after 21days of air dry curing.*

***Key Words*: Soil Stabilization, Expensive soil, Bio enzyme- TerraZyme, Shear Strength, CBR**

1. INTRODUCTION

Engineers are often faced with the problem of constructing facilities on or with soils, which do not possess sufficient strength to support the loads imposed upon them either during construction or during the service life of the structure[8]. Expansive soils occur in the arid and semi-arid regions of the world and they cover almost twenty percent of the total land-mass in India.For better performance of structures built on such soils, the performance characteristics of such soils need to be improved. There are various methods that could be used to improve the performance of poor quality soils. Stabilization of soils is an effective method for improving the properties of soil. The choice of a particular method depends mainly on the type of soil to be improved, its characteristics and the type and degree of improvement desired in a particular application. Recently bio-enzymes have emerged as a new chemical for soil stabilization. Bio-enzymes are chemical, organic, and liquid concentrated substances which are used to improve the stability of soil. Bio enzymes are catalytic enzymes that speed up chemical reactions they work extremely fast in anaerobic or aerobic aqueous environment. A bio enzyme during soil stabilization breaks down the electric double layer between the clay and static water. By this the clay particles looses its inherent charge and looses the adhered static water layer. In this mechanism the clay particles segregate and are so fixed crystallographic ally that it prevents any further volume changes on exposure to water[9]. Bio-Enzyme is convenient to use, safe, effective and drastically improves the soil properties.

1.1 Objectives of Study

- To assess how much the chemical treatment with TerraZyme changed the relevant engineering properties of the soil.
- To find out the potential effectiveness of selected product.

2. LITERATURE REVIEW

Sureka Naagesh and S. Gangadhara (2010) studied about the Swelling properties of Expansive treated with Bio-enzyme. Soil treated with 2% bio enzyme shows that void ratio decrease from 0.98 to 0.86. But X-ray diffraction studies indicate that noticeable mineralogical changes did not occur in bio-enzyme treated soil. SEM indicates the untreated specimens displayed flocculated structure and bio-enzyme treated specimens exhibited dispersed structure.

G. P. Ganapathy, R. Gobinath, I. I. Akinwumi, S. Kovendiran,M. Thangaraj, N. Lokesh ,S. Muhamed Anas, R. Arul murugan, P. Yogeswaran, S. Hema (2016) investigated that the treatment of the mountain soil with the bio-enzyme made the soil more workable by reducing its plasticity, increased its strength and reduced its permeability. . The bio-enzyme improved the 28 days CBR value of the soil by 96 %.

C. Venkatasubramanian and G. Dhinakaran (2011) reported that bio enzymatic stabilization resulted significant increase in unconfined compressive strength and California bearing ratio for all the three soils tested with varying parameters.

3. MATERIALS AND METHEDOLOGY

3.1 Materials Soil

In this study, the soil under investigation is collected from Surat City situated in South Gujarat region of India having expansive soil called black cotton soil as top layer.

Table -1: Properties of Soil

Properties	Results
Specific Gravity	2.72
Grain Size Distribution	
Clay (%)	30
Silt (%)	56
Sand (%)	14
Atterberg Limits	
Liquid Limit (%)	60.26
Plastic Limit (%)	27.07
Plasticity Index (%)	33.13
Free Swell Index (%)	80
Shrinkage Limit (%)	13.40
Soil Classification	CH (Inorganic Clay of High Plasticity)
Standard Proctor Compaction Test	
Maximum Dry Density (kN/m^3)	15.10
Optimum Moisture Content (%)	25
Unconfined Compression Strength (kPa)	127.48

TerraZyme

- A commercially available organic, enzyme based stabilizer known as TerraZyme is used as additive to the soil. The main branch of bio-enzyme is Avijeet Agencies, Chennai, India and collected from Sub branch of Avijeet Agencies, Ahmedabad.
- TerraZyme 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 TerraZyme treated soils to be compacted more tightly together.
- TerraZyme resists being replaced by water, thus reducing the tendency of some clays to swell.
- TerraZyme promotes the development of cementitious compounds using the following general reaction:

$$H_2O + clay \xrightarrow{TerraZyme} calciumSilicate\ Hydrates$$

Table -2: Properties of TerraZyme

Properties	Value
Hazardous Components	None
Boiling Point	212 °F
Specific Gravity	1.05
pH Value	3.50
Total dissolved solids	19.7 ppm
Cation exchange capacity	3.87
Evaporating Rate	Same as Water
Solubility in Water	Complete
Appearance/Odour	Dark brown

3.2 Methodology

From the compaction results of untreated soil for different dosages the amount of TerraZyme require is found out for different tests soil sample preparation.

Density of soil=1.54 g/cc

Density=Weight/Volume

For dose 1: 200ml/1.5 m^3= 1.54 X1.5X1000=2310 kg

200 ml for 2310 kg of soil ; for 1 kg of soil= 0.086 ml of TerrZyme required.

Similarly for other dosage the amount of TerraZyme is calculated.

Table -3: Amount of TerraZyme calculation

Dosage No	Dosage for soil (ml/m^3)	Amount of TerraZyme require ml/kg
1.	200ml/1.5m^3	0.086
2.	200ml/1.0m^3	0.129
3.	200ml/0.5m^3	0.259
4.	200ml/0.25m^3	0.519

4. EXPERIMENTAL INVESTIGATION

4.1 Atterberg Limits results

As shown in table- 4 Atterberg limit test on the treated soil sample decreased with increasing dosage of TerraZyme.

Table -4: Atterberg Limits

Dosage No	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
0	60.20	27.07	33.13
1.	57.50	27.00	30.5
2.	55.50	26.5	29.00
3.	52.10	25.00	26.27
4.	48.00	24.5	24.50

4.2 Compaction test results

The optimum moisture content of the treated soil samples decreased as the dosage of TerraZyme increases. The maximum dry density of the treated soil samples increased as the dosage of TerraZyme increased as shown in Fig.1.

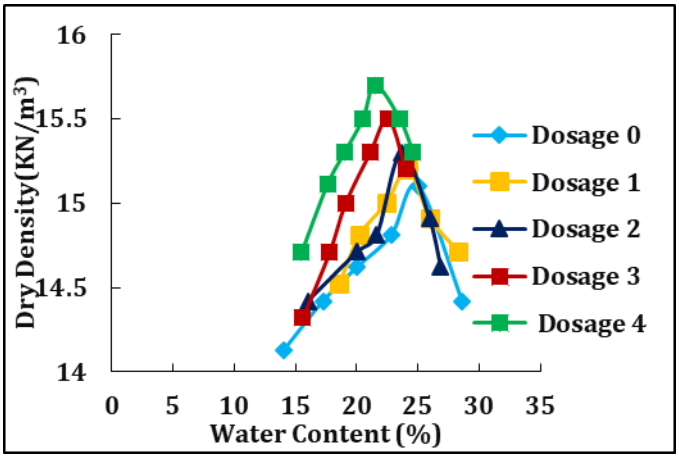

Fig.1 Variation of compaction characteristics

4.3 Unconfined Compressive strength results

The general increase in the strength of the soil sample, as the dosage increased may be attributed to aggregation and cementation of the soil particles.

The organic cations in the TerraZyme react with clay fraction of the soil and in the presence of water, it produced calcium silicate hydrate which is known to be the product of cementation.

From Fig.2 it is seen that for dosage no 4 Shear Strength of untreated soil increase from 127.48 kPa to 178.48, 213.96 and 220.10 kPa after 7,14 and 21 days respectively.

For minimum dosage no1 as 200ml/1.5m³ UCS value increase from 127.48 kPa to129.15,134.76 and 154.04 kPa after 7,14 and 21 days respectively.

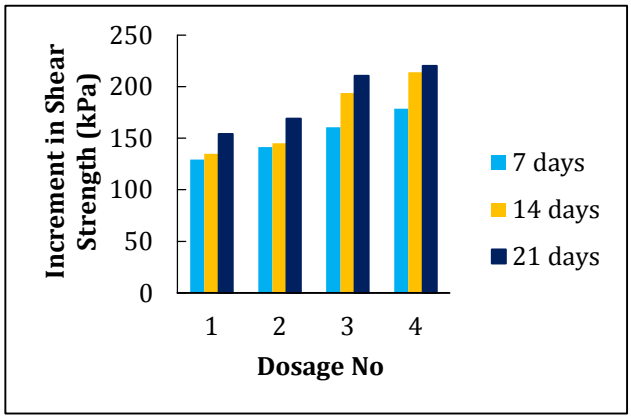

Fig.2 Increase in Shear Strength with increase in dosage and curing periods

4.4 California Bearing Ratio Result

For CBR test dosage no 4, 200ml/0.25m³ considered as the optimum dosage of TerraZyme for the soil, based on Atterberg Limit test, Compaction test and UCS test.

Expansive soil treated with 200ml/0.25m³ of TerraZyme and subjected to air-dry curing up to 21 days.

Table -5: CBR test results

CBR Value		
Curing Periods (Air-dry)	0 days	21 days
Untreated Soil	-	2.60
Soil + Dosage no 4	-	15.08

5. CONCLUSIONS

- The application of 200ml/0.25m³ TerraZyme reduced the Liquid Limit from 60.20% to 48% and Plasticity Index from 33.13% to 24.50%.
- Compaction test result shows that liquid chemical caused a modest increase in maximum compacted density and a slight decreases in optimum moisture.
- Best result in UCS value is for soil treated with 200ml/0.25m³. It shows the percentage improvement in shear strength up to 67.84% and 72.65% after 14,21 days respectively.
- After 21 days of unsocked air-drying CBR test shows the percentage improvement in CBR value is 480%.

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