IMPROVEMENT OF STRENGTH CHARACTERISTICS OF BIO ENZYME-TERRAZYME TREATED EXPANSIVE SOIL BY GYPSUM AS AN ADDITIVE

Usha Patel[1], Shalini Singh[2],Shivani Chaudhari[3]

[1] *Assistant professor of Applied Mechanics Department, L.D. Collage of Engineering, Ahmadabad, India*
[2] *Assistant professor of Applied Mechanics Department, L.D. Collage of Engineering, Ahmadabad, India*
[3]*P. G. Student of Geotechnical Engineering, L.D. Collage of Engineering, Ahmadabad, India*

ABSTRACT

In India large surface deposits are covered by Expansive soil, which have tendency to undergo volume change due to change in water content with seasonal variation.The problem with expansive soils has been recorded all over the world. The Surat City situated in South Gujarat region in India have majority of top soil as black cotton soil. 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. The present study was conducted to investigate the performance of Gypsum on Bio Enzyme treated expansive soil. The Expansive soil stabilized with Bio-enzyme and Gypsum. The work investigates the effect of 2%, 4%, 6% Gypsum on TerraZyme treated soil with 200ml/1.5m^3, 200ml/1.0m^3,200ml/0.5m^{3}and 200ml/0.25 m^3. For different dosage of TerraZyme Atterberg Limits, Compaction test, UCS and CBR test was performed. Mainly study the influence on strength characteristics of 2%, 4%, 6% Gypsum with different dosage of TerraZyme treated soil after 7 days of curing periods. Also finding the effect of optimum dosage of 200ml/0.25 m^3 TerraZyme with 6% Gypsum on CBR value after 21 days of air dry curing.

Keyword: - *Expansive Soil, Soil Stabilization, Bio-enzyme TerraZyme, Gypsum, Shear Strength, CBR*

1. INTRODUCTION

Various types of civil engineering activities taking place on the expansive soil deposits. Due to the peculiar behavior of the expansive soils the structure constructed on them shows heavy sign of damage like cracking, sliding, heaving and the expenditure on annual repair and maintenance of such building and structure. For better performance of structures built on such soils, the performance characteristics of such soils need to be improved by soil stabilization. Extensive research has been conducted studying the application of traditional stabilization additives such as lime, cement and fly ash (Santoni et al. 2001). However, engineering research studying non-traditional stabilization additives such as Bio-enzymes are less documented. Also it is very difficult to find significant literature on gypsum as a stabilization agent for expansive clays. Gypsum has the potential to bind soil particles and as a result, to increase the strength of soil mixtures, especially in a dry environment. Gypsum is the main source of sulphates and results in the formation of ettringite in calcium treated alumina rich soil (Rajasekaran 2005; Abdi and Wild 1993).Small amount of gypsum reduces water absorption, linear swelling and swelling pressure of lime treated kaolinite but the use of higher gypsum levels produces substantial water absorption, extreme expansion and high swelling pressures (Wild et al. 1993). Gypsum supplies additional calcium ions concentration to the soil system which accelerates the TerraZyme-soil reactions, causing enhancement in formation of cementation compounds.

1.1 Objective of Study

- To assess how much the chemical treatment with TerraZyme changed the relevant engineering properties of the soil.
- To enhance the chemical reaction between soil and TerraZyme by Gypsum as an additive.

1.2 Literature Review

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.

Işık Yilmaz, Berrin Civelekoglu (2009) were found that the most important change quickly occurred in the first week, and curing period of 7 days was accepted as a cure time for optimum improvement in this study. They concluded that the gypsum improves the expansive clay soils significantly only up to an addition of 5%.

Aly Ahmed, Usama H. Issa (2013) investigated the effect of the soaking condition in a wet environment on the stability and durability of soft clay soil treated with recycled gypsum. The short curing times of 3 and 7 days exhibited a positive effect on the improvement of the stability, strength, and durability for the stabilised specimens subjected to soaking compared with the longer curing time of 28 days.

2. MATERIALS AND METHEDOLOGY

2.1 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 ^oF
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

Gypsum

- Powder form of Gypsum procured from Shiv corporation godown, Ahmedabad. Gypsum is calcium sulphate. The most common form of it is the dehydrate which means that each molecule of calcium sulphate has two water molecules associated with it. The calcium ion of the gypsum replace the weaker cations of the clay and induces a stronger bond between clay particles.

Table -3: Properties of Gypsum

Property	Value
Chemical Classification	Sulphate
Color	It may be Clear, odorless , white, gray, yellow, red, brown
Streak	White
Luster	Vitreous, silky, sugary
Specific Gravity	2.5
Chemical Composition	Hydrous calcium sulphate, $CaSO_4{\cdot}2H_2O$
Crystal System	Monoclinic

2.2 Methedology

- 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.
- After that with this dosage of TerraZyme 2%,4%,6% Gypsum is added with soil and samples are prepared.

Table -4: 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

3. EXPERIMENTAL INVESTIGATION

3.1 Atterberg Limits results

As shown in chart-1 Atterberg limits of the treated soil sample decreased with increasing dosage of TerraZyme.

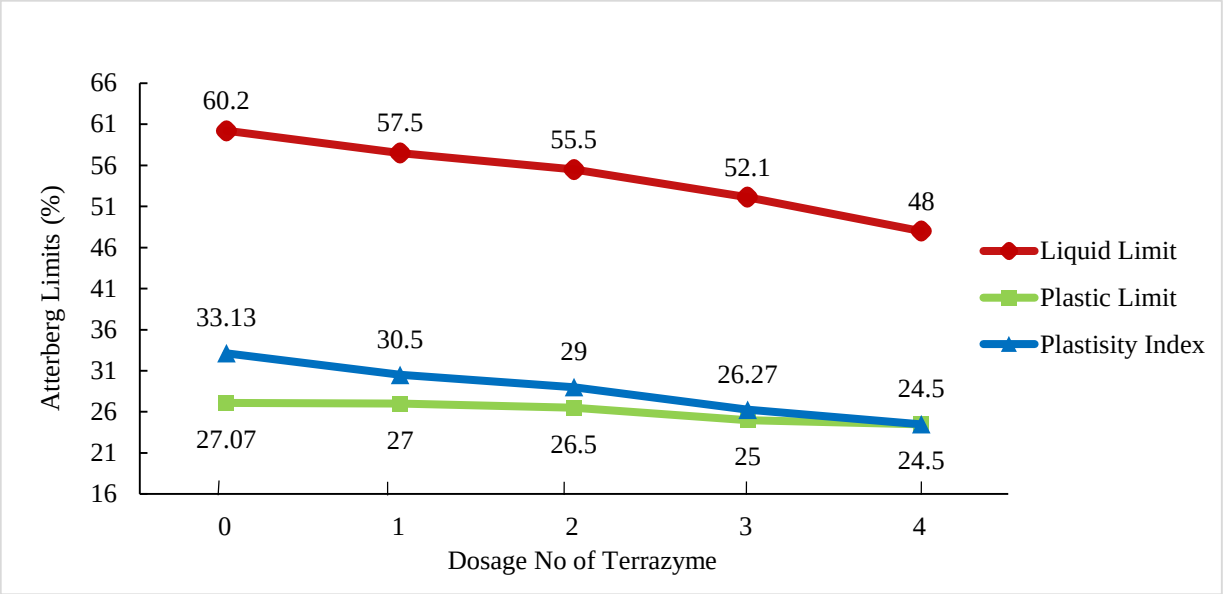

Chart-1:Comparison of Atterberg Limits

3.2 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 chart-2.

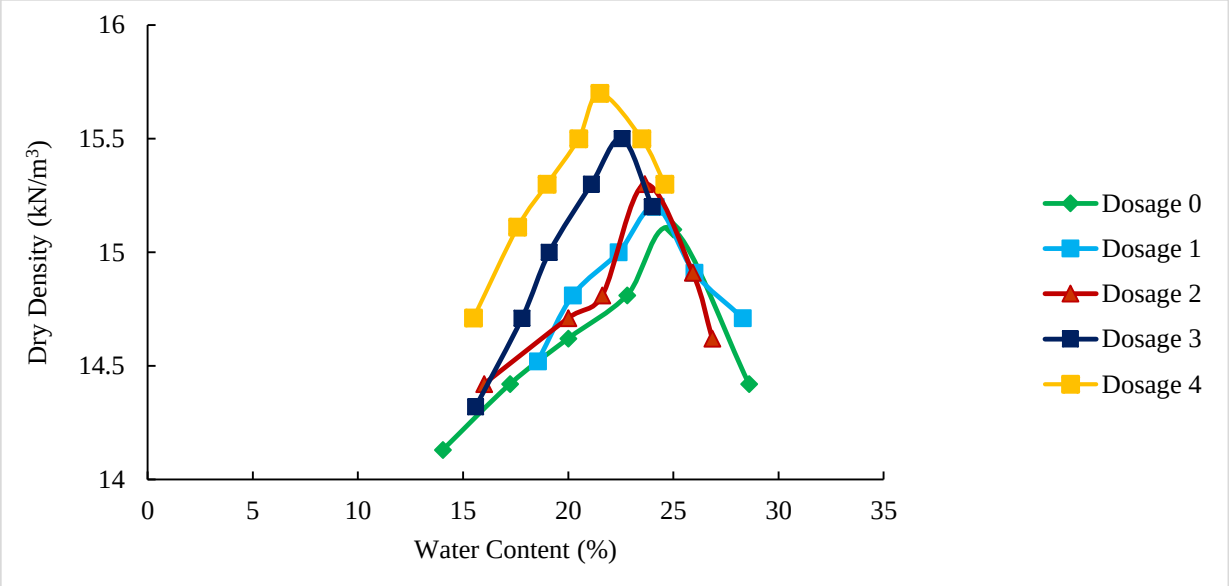

Chart -2: Variation of Compaction Characteristics

3.3 Unconfined Compressive Strength results of TerraZyme treated soil

From chart-3 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/1.5m^3 UCS value increase from 127.48 kPa to129.15,134.76 and 154.04 kPa after 7,14 and 21 days respectively.

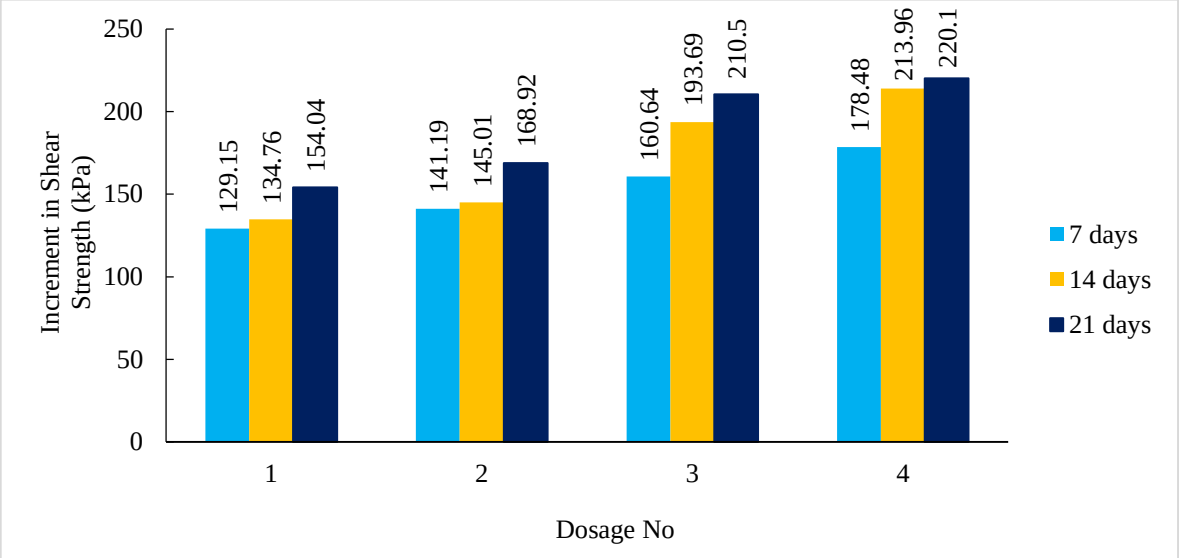

Chart -3:Increase in Shear Strength with increase in dosage and curing periods

3.4 Unconfined Compressive Strength results of TerraZyme and Gypsum treated soil

As seen from chart 4 there is much higher improvement in shear strength of TerraZyme and Gypsum treated soil in 7 days as compare to only TerraZyme treated soil. For maximum dosage of TerraZyme with 6% Gypsum increases in strength is upto 240 kPa.

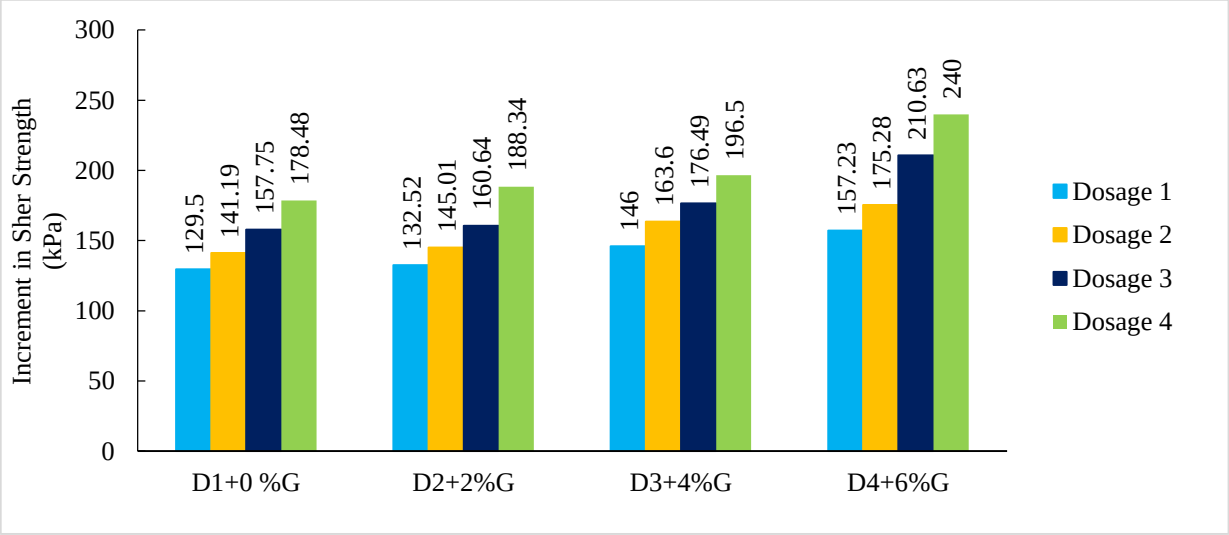

Chart -4:Increase in Shear Strength with increase in dosage of Gypsum

3.5 California Bearing Ratio test results

For CBR test dosage no 4, 200ml/0.25m^3 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/0.25m^3 of TerraZyme and

also with 6% Gypsum and 200ml/0.25m^3 of TerraZyme subjected to air-dry curing up to 21 days. Results are shown below.

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
Soil +Dosage no 4+6% Gypsum	-	20.24

4. CONCLUSIONS

- The application of 200ml/0.25m^3 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 240 kPa for soil treated with 200ml/0.25m^3 TerraZyme and 6% Gypsum. It shows the percentage improvement in shear strength up to 88.26 % after 7 days. It shows that the Gypsum increase the reaction time between soil and TerraZyme.
- Where as in TerraZyme treated soil for dosage 200ml/0.25m^3 strength increases upto 220.10 kPa for long curing periods of 21 days.
- After 21 days of unsocked air-drying CBR test shows the percentage improvement in CBR value is 480% for dosage no 4 and 678% for 6% Gypsum and 200ml/0.25m^3 TerraZyme treated soil.
- TerraZyme speed up a chemical reaction ,that would happen at a slower rate, without becoming a part of the end product.
- Main reason for improvement in TerraZyme treated soil is that the film of absorbed water is greatly reduced, which ultimately governs the expansion and Shrinkage of colloidal soil constituents.
- In Gypsum treated soil due to Cementing action with soil it induces a stronger bond between clay particles.

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