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A STUDY ON STABILIZATION OF EXPANSIVE SOIL USING TERRAZYME

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ABSTRACT

Due to rapid industrialization, availability of land is depleting in the developing nations like India. Because of this scenario it is required to utilize the problematic land for various construction activities. Various problematic soils are expansive soils, loess, collapsible soils, dispersive soils etc. These soils can be used for construction purpose only after adopting suitable ground improvement techniques. Though several methods are available to improve the problematic soils, chemical stabilization is best suited for improving expansive soil. Lime and fly ash are the traditional chemical stabilizers used for improving the characteristics of expansive soil. However, due to advancement in the field of construction industry, several other chemical stabilizers also available for stabilizing the expansive soils which requires detailed investigation. Terrazyme is such a stabilizer which started gaining attention of the researchers. The soil is treated with Terrazyme independently and tested for the index properties i.e. liquid limit, plastic limit and shrinkage limit and UCC strength characteristics for 7, 14 and 28 days of curing. The test results indicate that the plasticity characteristics of soil treated with Terrazyme decreased with increase in percentage of Terrazyme and curing period. The shrinkage limit values are increased upon stabilization by Terrazyme. Similarly the UCS values increased with increase in percentage of Terrazyme and curing period. From the present study it is brought out that Terrazyme can also be used to improve the properties of expansive soil.

I.INTRODUCTION

Several parts of arid and semi-arid regions of the world particularly Australia, Canada, China, India, Israel, South Africa and the United States are covered by expansive soils. Expansive soils, typically exhibit moderate to high plasticity, low to moderate strength and high swell-shrink characteristics (Holtz and Gibbs 1956; Sherwood 1962; Puppala et al 2006, Nasrizar et al 2010). Urbanization and industrialization forces the utilization of land with unsuitable soil by improving its properties by using appropriate ground improvement technique in order to meet the engineering requirement. Stabilization of expansive soil by using chemicals is one of the popular methods of improving the properties of expansive soil (Bell, 1993). The addition of lime to such soils to improve their engineering properties so that the stabilized soil could be used for construction purposes has a very long history. For instance, McDowell (1959) mentioned that stabilized earth roads were used in ancient Mesopotamia and Egypt, and that the Greeks and Romans used soil-lime mixtures.

Many researchers concentrated on improving the properties of expansive soil using traditional chemical stabilizers like lime and fly ash, since chemical stabilizers are mostly preferred to stabilize expansive soils. It is a proven fact that these stabilizers improve the engineering properties of expansive soil significantly. Since construction industry is growing in an exponential order, several other chemicals are commercially available which are used during construction. One such chemical used for improvement is Terrazyme. (Agarwal & Kaur, 2014; Lekha et al 2013; Saini & Vaishnava, 2015; Swathy et al, 2015; Vinayaga Mourthy, 2010), But, the effect of these modern chemicals on improving the engineering properties of expansive soil is not well documented. Therefore, the present study aims to carryout extensive experimental study on the effect of Terrazyme on index properties and strength of expansive soil.

In this study, an expansive soil is treated with different percentages of a Terrazyme which was cured for 7, 14 and 28 days and then liquid limit, plastic limit and shrinkage limit tests are conducted to obtain index properties and also unconfined compressive strength test is conducted to get strength of stabilized soil.

II.MATERIALS

A. Soil

All the experiments were conducted using a Soil collected at a depth of 3 to 5 m from Chennai, Tamilnadu, India. According to the procedure given in respective Indian Standard (IS) recommendations, grain size distribution analysis, Atterberg limits tests, Proctor compaction test and unconfined compressive strength tests are conducted on natural soil. The properties of the natural soil are summarized in Table 1. The soil composed of 2% gravel, 19% sand, 8% silt and 71% clay. The soil showed liquid limit of 68%, plastic limit of 27%, plasticity index of 41%, shrinkage limit of 20% and differential free swell index of 60%. As per Indian Soil Classification system, the soil is classified as Clay of High plasticity (CH).

B. Terrazyme

A bio enzyme is used as additive to stabilize the soil in this study. Terrazyme is basically a bio enzymatic product has been used in various part of world for the improvement of pavements. Terrazyme is non toxic, non corrosive and inflammable liquid which can be easily mixed with water. Terrazyme improves the properties of soil and strength of soil significantly. The properties of Terrazyme are shown in Table 2.

C. Experimental Programme

Experiments were conducted on natural soil mixed with 0.2, 0.3 & 0.4 ml of Terrazyme per kg of sample and the soil-chemical mix is cured for 7, 14 and 28 days prior to testing. The various tests conducted are liquid limit, plastic limit and shrinkage limit tests and also unconfined compressive strength test.

TABLE 1

PROPERTIES OF NATURAL SOIL

Properties	**Value**
Gravel (%)	2
Sand (%)	19
Silt (%)	8
Clay (%)	71
Liquid limit (%)	68
Plastic limit (%)	27
Plasticity index (%)	41
Shrinkage limit (%)	10
Free swell index (%)	60
Soil classification	CH
Optimum Moisture Content (%)	19.22

Maximum Dry unit weight (kN/m^3)	16.1
Swell pressure (kN/m^2)	200
Swell classification	High

TABLE 2

CHEMICAL COMPOSITION OF TERRAZYME

Property	**Value**
Specific gravity	1.000-1.090
pH value	3.10 - 5.00
Appearance	liquid
Odour	characteristic odour
Flammability	Inflammable
Solubility	Infinite
Colour	Brown
Boiling point	2120F

III. RESULTS AND INTERPRETATION

A. Influence of Terrazymes on the properties of soil

The index properties such as liquid limit, plastic limit and shrinkage limit plays a vital role in understanding the engineering behavior of fine grained soil. Irrespective of the soil conditions many empirical correlations have been developed to predict engineering behavior of fine grained soil based on index properties. Atterberg limits are found to correlate with the engineering behavior of soils because both the Atterberg limits and engineering properties are found to be influenced by the same factors such as the clay minerals, the ions in the pore water and the stress history of the soil deposit.

Fine silts and clays, whose strength is influenced by cohesion is determined from unconfined compressive strength test. The peak values of stress strain curve are designated as unconfined compressive strength test. Unconfined compressive strength test were conducted on samples treated with various percentages of chemicals. The influence of various chemicals on the index and strength properties is dealt in following sub sections.

B. Effect of Terrazyme on Index properties and strength

Effect of different percentage of Terrazyme on index properties (liquid limit, plastic limit, plasticity index, shrinkage limit) and UCC strength have been presented in Tables 3 to 5.

C. Effect of percentage of Terrazyme on index properties

Figure 1 shows the variation of liquid limit with curing periods for the Terrazyme dosage of 0.2 ml/kg, 0.3 ml/kg and 0.4 ml/kg of soil. It is observed that liquid limit marginally decreases with curing period and with dosage of Terrazyme added. For 7 days curing period the liquid limit reduces from 68% to 65% for the dosage of 0.3 ml/kg. The liquid limit reduces from 68% to 64.4% for 28 days curing period.

Figure 2 shows the variation of plastic limit for different dosages of Terrazyme with various curing period. The plastic limit has increased slightly from 27% to maximum of 29% with the difference of only 2%. The maximum increase in plastic limit is for enzyme dosage of 0.3 ml/kg of soil for the curing period of 28 days.

Shrinkage limit is an indicative of the structure and swell nature of the soil. For any given soil, the soil with flocculent fabric shrinks lesser than dispersed structure. Figure 4 shows the variation of shrinkage limit with different curing period. The graph shows increase in

TABLE 3

INFLUENCE OF TERRAZYME ON PLASTICITY CHARACTERISTICS AND UCC STRENGTH FOR 7 DAYS CURING

Dosage of	**0**	0.2	0.3	0.4
Liquid Limit (%)	68	66	65.5	65
Plastic Limit (%)	27	26.6	27	28
Plasticity Index	41	39.4	38.5	37
Shrinkage Limit	10	15	14.1	14.3
UCS (kN/m^2)	195	207	**311**	320

TABLE 4

INFLUENCE OF TERRAZYME ON PLASTICITY CHARACTERISTICS AND UCC STRENGTH FOR 14 DAYS CURING

Dosage of	**0**	0.2	0.3	0.4
Liquid Limit (%)	68	65.4	65.1	64.6
Plastic Limit (%)	27	27.2	28.1	28.3
Plasticity Index	41	38.2	37	36.3
Shrinkage Limit	10	16	16.3	17
UCS (kN/m^2)	195	300	**348**	321

TABLE 5

STUDY INFLUENCE OF TERRAZYME ON PLASTICITY CHARACTERISTICS AND UCC STRENGTH FOR 28 DAYS CURING

Dosage of	**0**	0.2	0.3	0.4
Liquid Limit (%)	68	65.2	65	64.4
Plastic Limit (%)	27	27	28.4	29
Plasticity Index	41	38.2	36.6	35.4
Shrinkage Limit	10	17	17.5	17.5
UCS (kN/m^2)	195	331.6	400.93	373.8

shrinkage limit with increase in curing period. This is due to fact of cation exchange capacity. In clay water mixture positively charged ions are present around the clay particles, creating a film of water around the clay particles that remains attached or adsorbed on the clay surface. The adsorbed water gives clay particle their plasticity. To improve the soil property it is necessary to reduce the thickness of double layer. Cation exchange process can accomplish this. By utilizing fermentation process specific micro organism can produce stabilizing enzyme. When exposed to the air, the microorganisms multiply rapidly and produce large organic molecules, which the enzyme attaches to the clay platelets. These soil stabilizing enzyme catalyze the reactions between the clay and the organic cations and accelerate the cation exchange without becoming the part of end product.

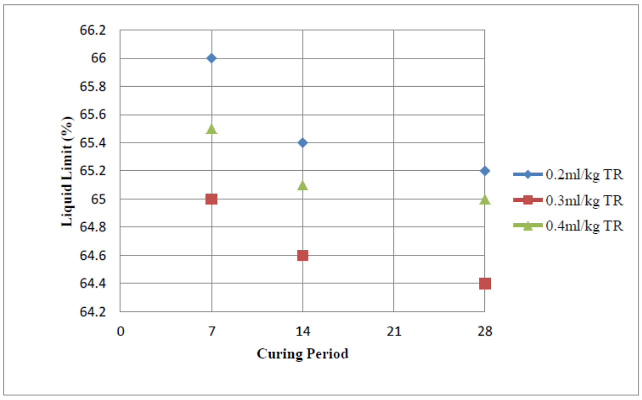

Fig.1. Liquid limit vs curing period for various percentage of Terrazyme

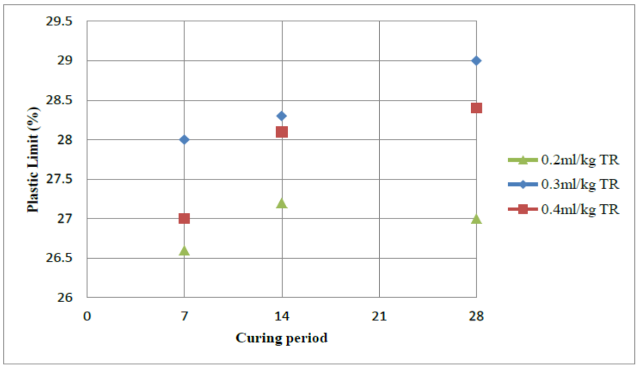

Fig.2. Plastic Limit vs curing period for various percentage of Terrazyme

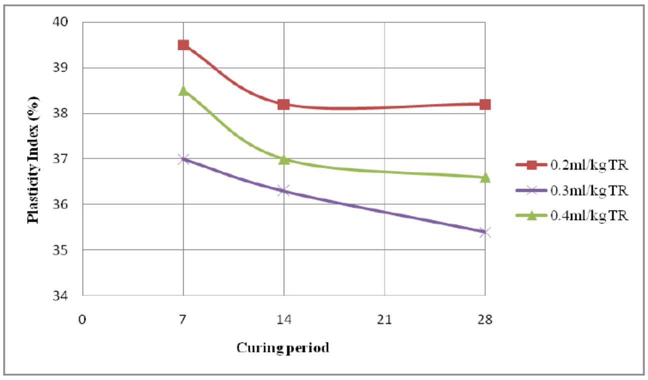

Fig.3. Plasticity Index vs curing period for various percentage of Terrazyme

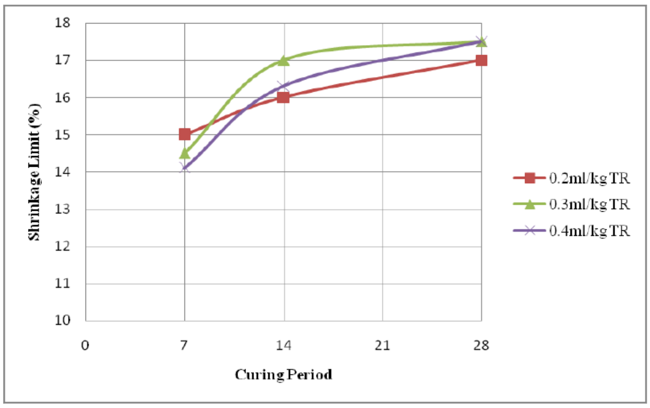

Fig.4. Shrinkage Limit vs curing period for various percentage of Terrazyme

D. Effect of percentage of Terrazyme on strength properties

Remoulded specimens were prepared using three levels of Terrazyme. The Terrazyme mixed soil was also cured for the period of 7, 14 and 28 days. Figures 5 to 7 show the variation of axial stress with axial strain for various dosages of Terrazyme for 7, 14 and 28 days curing period respectively. From Figures 5 to 7 it can be seen clearly that strength increases for all dosages of Terrazyme. It can be seen from the figure 5 that the sample fails at maximum axial stress of 207 kPa, 311 kPa and 320 kPa for Terrazyme dosage of 0.2 ml/kg, 0.3 ml/kg and 0.4 ml/kg respectively. From the dosages considered in the present study it is observed that 0.3 ml/kg gives higher UCS except for 7 days curing.

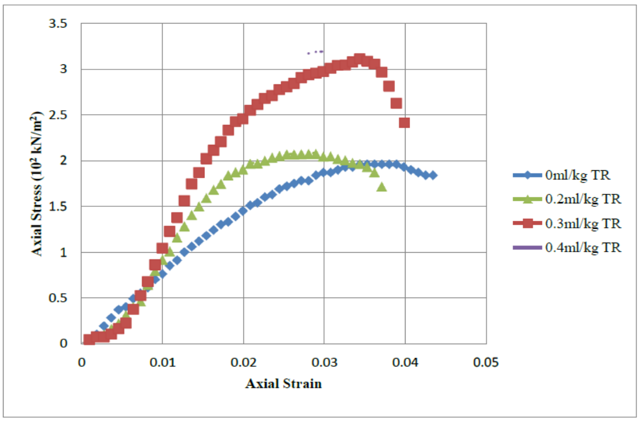

Fig.5. Stress-strain relationships for Terrazyme stabilized soil after 7 days curing period

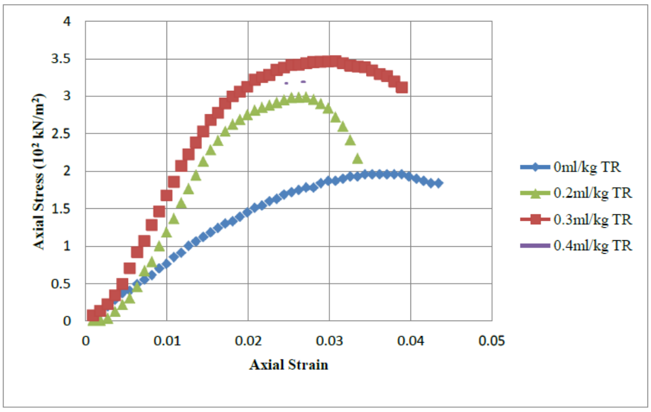

Fig.6. Stress-strain relationships for Terrazyme stabilized soil after 14 days curing period

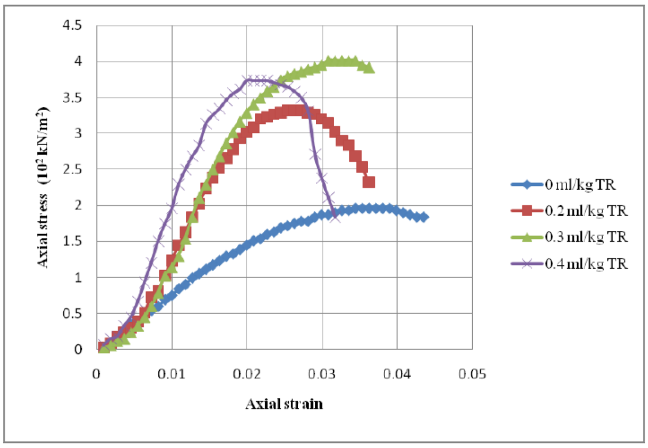

Fig.7. Stress-strain relationships for Terrazyme stabilized soil after 28 days curing period

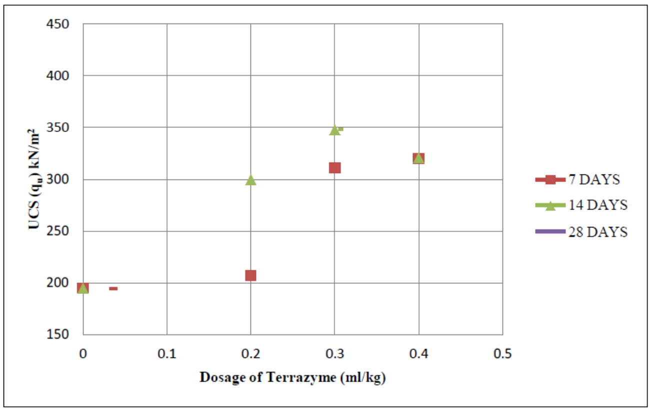

Fig.8. Variation of UCS of stabilized soil cured for 7, 14 and 28 days with different percentages of Terrazyme

The peak value of stress was obtained from the stress-strain curves which are designated as unconfined compressive strengt (UCS). Figure 8 show the variation of UCS with different dosage of Terrazyme for all curing period. It shows increase in strength with increase in curing period. The increase in strength was found to be higher for 0.3 ml/kg Terrazyme dosage for higher curing days. This increase in strength is due to the enzymatic reaction of Terrazyme with adsorbed layer on surface of clay particles. 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. These factors can promote the superior density and inturn leads to higher strength.

IV. CONCLUSION

In order to understand the effect of Terrazyme on the index and engineering characteristics of expansive soil, tests were conducted on soil samples with increasing percentage of Terrazyme and duration of curing period. The general conclusions drawn from the analysis of test results are further below.

1. Addition of Terrazyme, decreases the liquid limit and increases the plastic limit which in turn decreases plasticity index values of soil. The reduction in plasticity characteristic has been attributed to the suppression of double layer thickness caused by cation exchange of high valency ions. Reduction in plasticity behavior reduces the swelling nature of soil.

2. The shrinkage limit of soil treated with Terrazyme has increased moderately with increase in percentage of chemical and curing period. The higher the shrinkage limit lower is its swell-shrinkage behavior of soil.

3. The unconfined compressive strength was increased for any percentage of Terrazyme. The increase in strength for Terrazyme treated soil was 2 folds higher than that of untreated soil for dosage of 0.3 ml/kg.

4. The soil samples treated with Terrazyme shows ductile nature of failure

5. The strength increases as the curing period increases for Terrazyme.

A. General conclusion

The study was intended to look for the possibility of using Terrazyme for the improvement of problematic soil as a substitute for ordinary commercial chemical such as Lime, owing to the specific advantage of these chemicals. The Terrazyme when mixed with soils reduces the plasticity characteristics and enhances the strength soil considerably. Hence it is concluded that Terrazyme can also be used to improve the characteristics of expansive soil.

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