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An Experimental Study on Stabilization of Soils by Using Bio-Enzymes

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ABSTRACT

The present study, an attempt is made to study the properties of soil stabilized with the Terrazyme, in order to use this technology for Geotechnical applications. Laboratory investigations are carried out blending Terrazyme with soil in different dosages and the effect is studied. A series of Standard Proctor tests, Soaked and Unsoaked California Bearing Ratio (CBR) test, and Unconfined Compressive Strength tests were conducted on locally available clayey soil as well as clayey soil mixed with different proportions of Terrazyme in order to study the improvement of strength properties of Terrazyme stabilized the soil. The specimen are compacted to their respective MDD at optimum moisture content. Results show that the terrazyme can successfully be used to stabilize the soil. Significant improvement was found in both Soaked CBR and Unconfined Compressive Strength.

INTRODUCTION

The growth of the population has created a need for the better and economical vehicular operation which requires good highways having a proper geometric design, pavement condition and maintenance. Many areas of India consist of soils with high silt contents, low strengths and minimal bearing capacity. These negative soil performance characteristics are generally attributed to the nature and quality of the fines present in the material. When poor quality soil is available at the construction site, the best option is to modify the properties of the soil so that it meets the pavement design requirements. This has led to the development of soil stabilization techniques.

Since the nature and properties of natural soil vary widely, a suitable stabilization technique has to be adopted for a particular situation after considering the soil properties. Soil improvement by mechanical or chemical mean is widely used. Recently Bio-Enzymes has emerged as a new chemical for stabilization. Bio-Enzymes are chemicals, organic and liquid concentrated substances which are used to improve the stability of soil of soil sub-base of pavement structures. Bio-enzyme is convenient to use, safe, effective and dramatically improve road quality. The objective of any stabilization technique used are to increase the strength and stiffness of soil, improve workability and constructability of the soil and reduce the plasticity index.

The objective of the study

1. To characterize the effect of Terrazyme on the soil.
2. To study the effect of varying dosages of Terrazyme on strength and other characteristics of identified soils.
3. To find out optimum Terrazyme dosage required for selected soils.
4. To compare the results obtained from the enzyme with virgin soil.

Dosages of Bio enzyme:

The enzyme dosage varies from 200 ml/3.0m3 to 200 ml/1.5m3 of the soil, and it depends upon soil properties.
In this experimental investigation, the Enzyme Dosages assumed for Expansive Clayey soil was 200 ml for bulk volume 3.5 m3 to 1.5 m3 of soil.

Bulk Density of BC soil = 1.56 g/cc
Bulk Density = Weight / Volume
Weight = Bulk Density x Volume

For Dosage 1
200 ml for 3.0 m3 of soil = 1.56 x 3.0 x 1000 = 4680 kg of soil
For 1 kg = 0.042 ml of Enzyme

For Dosage 2
200 ml for 2.5 m3 of soil = 1.56 x 2.5x 1000 =3900 kg of soil
For 1 kg = 0.051 ml of Enzyme

For Dosage 3
200 ml for 2.0 m3 of soil = 1.56 x 2.0 x 1000 = 3120 kg of soil
For 1 kg = 0.064 ml of Enzyme

For Dosage 4
200 ml for1.5 m3 of soil = 1.56 x 1.5 x 1000 = 2340 kg of soil
For 1 kg = 0.085 ml of Enzyme.

Table1. Enzyme Dosages

Dosage	200 ml/m^3	Ml/KG of soil
1	3	0.042
2	2.5	0.051
3	2	0.064
4	1.5	0.085

Mechanism of Soil Stabilization by Bio-Enzyme:

In clay water mixture positively charged ions (cat-ions) are present around the clay particles, creating a film of water around the clay particles that remain attached or adsorbed on the clay surface. The adsorbed water or double layer gives clay particles their plasticity. In some cases the clay can swell and the size of double layer increases, but it can be reduced by drying. Therefore, to truly improve the soil properties, it is necessary to permanently reduce the thickness of the double layer. Cat-ion exchange processes can accomplish this. By utilizing fermentation processes specific microorganisms can produce stabilizing enzyme in large quantity. The soil stabilizing enzymes catalyze the reactions between the clay and the organic cat-ions that accelerate the cat-ionic exchange without becoming part of the end product.

Bio-Enzyme (Terrazyme) replaces adsorbed water with organic cat-ions, thus neutralizing the negative charge on a clay

H_2o+ clay +**Terrazyme** -------------calcium silicate hydrates

List of Tests carried in
Phase 1:
1. Sieve Analysis
2. Specific Gravity
3. Liquid Limit
4. Plastic Limit
5. Differential Free Swell

Liquid limit:
About 120g of air dried soil passing through IS sieve 425 microns is taken and mixed with water such that the soil attains a putty-like consistency. A portion of the paste is placed in the cup and is leveled so as to have a maximum depth of about 10mm. A groove is cut in the soil placed in the cup, using the grooving tool. In cutting the groove, the grooving tool is drawn through the sample along the symmetrical axis of the cup, holding the tool perpendicular to the cup. The handle is rotated at the rate of 2 revolutions per second and the number of blows necessary to close the groove for a distance of 13mm is noted. About 10g of soil near the closed groove is taken to determine its water content. A liquid limit is determined by reading the water content corresponding to 25 blows from the flow curve. The graph is then plotted between a number of blows N on a logarithmic scale and the water content (w) on a natural scale.

Fig 1: Casagrande's Liquid Limit Device

Compaction of Soil:
Compaction is the process of densification of soil by reducing air voids. The degree of compaction of a given soil is measured in terms of its dry density. The dry density is Maximum at the optimum water content. A curve is drawn between the water content and the dry density to obtain the maximum dry density (MDD) and the optimum water content (OMC).

Dry Density=M/V1+w

Where, M = Mass of the Compacted Soil, V=Volume of the Soil, w = Water Content

To determine the compaction characteristics of a soil specimen, there are two methods were present.

Light Compaction:
In this light compaction method, the standard cylindrical mould of capacity 1000cc with an internal diameter of 10KG and height 12.73 KG is used to determine the compaction characteristics of the soil sample. The weight of the hammer used in this is 2.6 kg with free drop 3.1KG. The soil is compacted in 3 layers and each layer is tamped to 25 times

Heavy Compaction:
The volume of the mould used in this compaction test is 2250cc with an internal diameter of 15KG and height of 12.73KG. Weight of the rammer used in this test is 4.89 kg with a free drop of 45KG. The soil is compacted in 5 layers and each layer is tamped to 25 times.

Fig 2: Types of moulds and rammers used in Light and Heavy compaction

Test Procedure:
Take about 4.5 to 5.5kg of the soil which was passed through 20mm and retained in 45mm sieve. Insert the spacer discover the base and place coarse filter paper disc on the top of the displacer disc and fix the mould and collar on it. Mix the soil with water at OMC which was obtained in the compaction test. And compact the soil in 5 layers by giving 56 blows with heavy compaction rammer (4.89kg weight with 45KG drop) to each layer. Remove the extension collar and trim even the excess compacted soil carefully with a straight edge. Loosen the base plate and remove the spacer disc and invert the mould. Add annular masses to produce surcharge equal to 2.5 kg. A minimum of two annular masses should be placed.

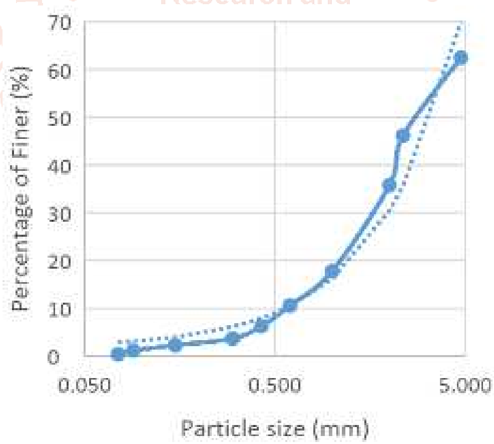
Place the mould containing specimen in loading machine and apply the load on the plunger. Keep the rate of penetration as 1.25 mm/min. record the load corresponding to penetration 0.55,1.0,1.5,2.0,2.5,3.0,3.5, 4.0,5.0,7.5,10.0,and 12.5mm. However, record the maximum load and the corresponding penetration if it occurs at penetration of less than 12.5mm.

To calculate the Soaked CBR, Immerse the prepared sample with mould assembly in a tank full of water. Allow free access of water to the top and bottom of the specimen. Keep the mould in the tank undisturbed for 96hours. Take out the soaked specimen after 96hrs, allow it to drain of for 15min without disturbing the specimen. And the follow the procedure on load machine to calculate the soaked CBR.

Fig 3: CBR Testing Table 5.1: Sieve Analysis:

Table 2

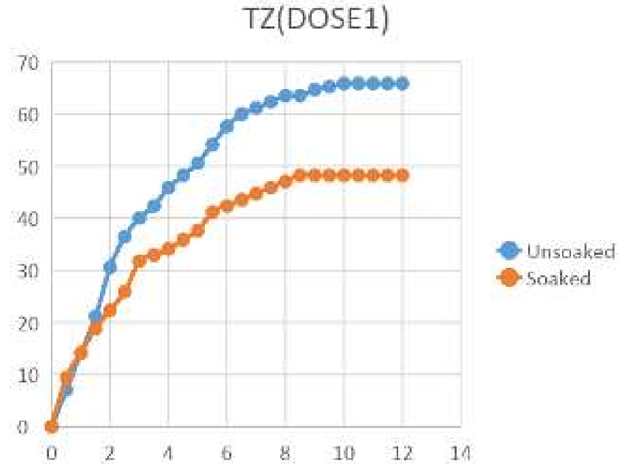
IS Sieve	Weight Retained (g)	Percentage Retained (%)	Cumulative Percentage (%)	Percentage of Finer (%)
4.750	375	37.5	37.50	62.5
2.360	163	16.3	53.80	46.2
2.000	104	10.4	64.20	35.8
1.000	180	18	82.20	17.8
0.600	72	7.2	89.40	10.6
0.425	43	4.3	93.70	6.3
0.300	26	2.6	96.30	3.7
0.150	14	1.4	97.70	2.3
0.090	11	1.1	98.80	1.2
0.075	8	0.8	99.60	0.4
PAN	4	0.4	100.00	0



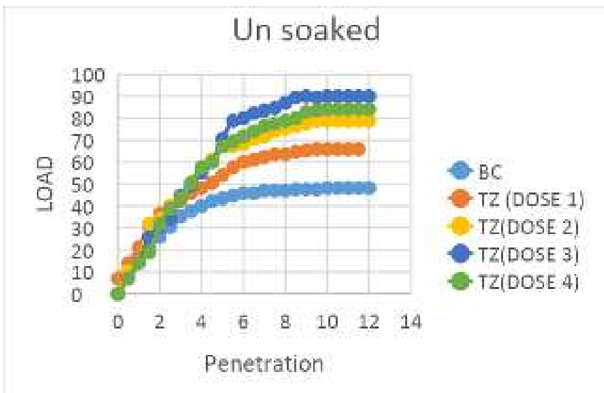
Graph 1: Sieve Analysis Graph

Table 3: Compaction Test Observation table for black Cotton soil:

Content	% of water				
	5%	10%	15%	20%	25%
Empty Weight of mould,	4980	4980	4980	4980	4980
Weight of mould + compacted soil,	8601	8916	9276	9280	9209
Weight of compacted soil,	3621	3936	4296	4300	4229
Weight of cup	36	36	36	36	36
Weight of cup + wet soil	43	47	59	56	51
Weight of cup + dry soil	42	46	55	52	48
Weight of soil	11	10	19	16	12
mass of water	1	1	4	4	3
water content , W	9	10	21	25	25
Bulk density	1.61	1.71	1.91	1.91	1.88
dry density	1.48	1.56	1.58	1.58	1.52



Graph 2: Load Vs Penetration graph for Black Cotton Soil+ TZ (Dose1) (Unsoaked & Soaked)



Graph 3: Load Vs Penetration graphs of Unsoaked CBR at different percentages of TZ

CONCLUSIONS

In this study, the major properties studied are OMC, MDD, CBR, UCS, and Consolidation. Based on all investigations on all samples and when compared with normal soil, the following conclusions were made:

Performance of Bio-Enzyme stabilized soil has been investigated in this work. Based on the tests conducted in the laboratory, the following conclusions were drawn:

- ➢ Amount of clay content plays a major role in the variation of consistency limits. It is found that the liquid limit decreases from 55% to 48% while the plastic limit reduces from 26% to 24% at the dosage no.4
- ➢ Changes are marginal for MDD of enzyme-treated soil which is from 1.486 gm/cm3 to1.78 gm/cm3 whereas a decrease in OMC is observed to be 24 to 25%. The decrease is due to the effective cation exchange process which generally takes a longer period in the absence of such stabilizers.
- ➢ The UCS value increases from 1.12 KN/m2 to 5.54 KN/m2 This is due to the reaction of the enzyme with clay which results in cementation effect.
- ➢ It is observed that the treated soaked CBR values are increased as the curing period's increase which is because soil treated with enzyme renders improved density values by reducing the void ratios. Initially for the local soil the soaked CBR value was 1.19% but with stabilization after 4weeks of curing the soaked CBR value was 3%

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