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Stabilization of Black Cotton Soil using Terrazyme

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Abstract:
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, facilitates higher soil compaction densities and increases stability. Enzyme catalyze the reactions between the clay and the organic cat-ions and accelerate the cat-ionic exchange process to reduce adsorbed layer thickness. For other types of chemical stabilization, chemicals are mixed with soil, which is difficult to mix thoroughly, but bio-enzyme is easy to use as it can be mixed with water at optimum moisture content and then it is sprayed over soil and compacted. In this study Black cotton soil with varying index properties have been tested for stabilization process and strength of the stabilized soil were evaluated after for various enzyme dosages 200ml/3m3, 200ml/2.5m3, 200ml/2m3, 200ml/1.5m3. The tests which were carried out are the California Bearing Ratio (CBR) test and Unconfined Compressive strength (UCS) test of the soil specimen. The test results indicate that bio-enzyme stabilization improves the strength of BC soil up to great extent, which indicate the bearing capacity and the resistance to deformation increases in stabilized soil. An attempt has been made to study the properties of soil modified with the bio-enzyme , in order to use this technology for low volume roads. Based on laboratory findings, field trials were carried out using bioenzyme in some of roads in India. Moreover, in case of scarcity of granular material, only bio-enzyme stabilized surface with thin bituminous surfacing also can fulfil the pavement design requirement. Adopting the IRC method based on soil CBR, the pavement design thickness on stabilized soil also reduces 25 to 40 percent.

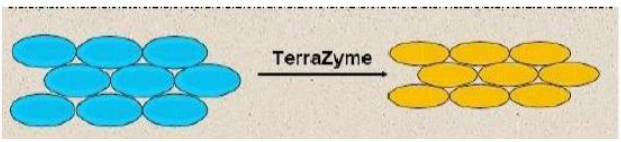
Keywords: Bio-Enzyme, Terrazyme, Soil Stabilization, Black Cotton Soil, CBR and UCS.

1. INTRODUCTION

The necessity of improving the engineering properties of soil has been recognised for as long as construction has existed. Many ancient cultures including the Chinese, Romans and Incas utilised various technics to improve soil suitability, some of which were effective that many of buildings and road ways they constructed still exist today.The modern era of soil stabilisation begin during 1960-1970 when the general shortages of aggregates and fuel resources forced engineers to consider alternatives to conventional technics of replacing poor soil. More recently, soil stabilization has once again become a popular trend as a global demand for raw materials, fuel and infrastructure has increased. Terrazyme is natural, non-toxic,non-corrosive, bio degradable liquid it can be easily mixed with water at the optimum moisture content. The main aim of this product is to efficiently use of locally available material. The most common application of stabilization of soil is seen in construction of road and air field pavement. The chemical stabilization is done by adding chemical additives to the soil that physically combines with soil particles and alter the geotechnical properties of soil. Enzymes enhance the soil properties and providing higher soil compaction and strength. The most commonly application of stabilization of soil is seen in construction road and air filled pavement.

1.1 SOIL STABILIZATION

Soil stabilization is the alteration of one or more soil properties, by mechanical or chemical means, to create an improved soil material possessing the desired engineering properties. Soils may be stabilized to increase strength and durability or to prevent erosion and dust generation. Regardless of the purpose for stabilization, the desired result is the creation of a soil material or soil system that will remain in place under the design use conditions for the design life of the project. There are various methods for soil stabilization like mechanical stabilization, cement stabilization, lime stabilization, bituminous stabilization, chemical stabilization, thermal stabilization, electrical stabilization, stabilization by grouting etc. 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 remains 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 double layer. Cat-ion exchange processes can accomplish this. By utilizing fermentation processes specific micro organisms can produce stabilizing enzyme in large quantity. The soil stabilizing enzymes catalyse the reactions between the clay and the organic cat-ions that accelerate the cat-ionic exchange without becoming part of the end product.



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

$$H_2O + \text{Clay} \xrightarrow{\textit{Terrazyme}} \text{Calcium Silicate Hydrates}$$

2. OBJECTIVES:

1. To determine the effect of Terrazyme on the index properties of soil.

2. To determine the effect of Terrazyme on compaction characteristics of soil.
3. To determine the effect of Terrazyme on C.B.R value of soil.

2.1 Necessity:

1. As a prelude to begin with a project it is more essential to have general and detailed information regarding the subject content, strategic approaches, available research in the subject area, interpreted results and drawn conclusions.
2. Keeping above in mind, a detailed review is conducted to know the available information in the subject is, need to research, development and improvements. It gives us an idea about the objective to be achieved from the present work. Literature review is carried out by referring the journals, dissertation reports, relevant IS codes and browsing the websites. The list of journals, books, website referred is given in reference section.

3. MATERIALS AND METHODS:

3.1 Black Cotton Soil:

Black cotton soil (BC soil) is a highly clayey soil. The black colour in Black cotton soil (BC soil) is due to the presence of titanium oxide in small concentration. The Black cotton soil (BC soil) has a high percentage of clay, which is predominantly montmorillonite in structure and black or blackish grey in colour. Expansive soils are the soils which expand when the moisture content of the soils is increased. The clay mineral montmorillonite is mainly responsible for expansive characteristics of the soil. The expansive soils are also called swelling soils or black cotton soils.

Figure.1. Soil used for investigation

3.2 Terrazyme:

TerraZyme is a liquid enzyme which is organic in nature and is formulated from the vegetable and fruit extract. It improves the quality of soil like CBR, durability and decreases the OMC, plasticity index of soil. The effect of TerraZyme on soil is permanent and the soil becomes bio degradable in nature. The reason behind the improvement of soil properties is the cat ion- ion exchange capacity of the clay. Friction among the soil particles increases as the water is expelled out from the soil. Terrazyme forms a protective coating around the clay particles and thereby making clay particles water repellent. These organic enzymes come in liquid form and are perfectly soluble in water, brown in color and smells like molasses. Irritation in eyes may be caused by TerraZyme sometimes but the handling of this enzyme is easy i.e., masks and gloves are not required. Dosage of TerraZyme is of utmost importance, if less amount of TerraZyme is mixed with soil the effects will not be satisfying which means soil will achieve less stability and if TerraZyme is overdosed it will result in the higher cost and stabilization will become ineffective. In order to find out the optimum dose of TerraZyme in particular soil series of CBR test is performed on each sample with different amount of TerraZyme.

BIO-ENZYME (TerraZyme)

4. ENZYME DOSAGE CALCULATION

The Enzyme Dosages assumed for Black cotton soil was 200 ml for bulk volume 3.5 m^3 to 1.5 m^3 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 m^3 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.

Enzyme Dosages

Dosage	200 ml/m^3 of Soil	ml/kg of Soil
1	3.0	0.042
2	2.5	0.051
3	2.0	0.064
4	1.5	0.085

5. METHODOLOGY:

5.1 TESTS CONDUCTED ARE:

- Specific gravity
- Practical size distribution
- Atterbrg Limits

- Compaction test
- Unconfined compression test
- California Bearing Ratio.

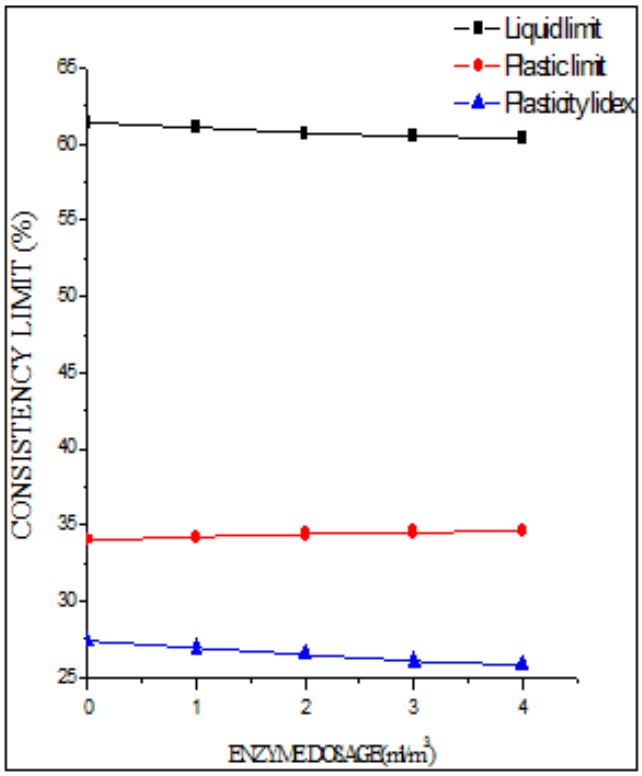
Determination of Specific gravity of soil sample

Sl.No	Observations	Weight in grams
1.	Weight of pycnometer(W1,g)	618
2.	Weight of pycnometer + dry soil (W2,g)	932
3.	Weight of pycnometer + dry soil + Water(W3,g)	1670
4.	Weight of pycnometer + water (W4,g)	1460
5.	Specific Gravity,G	2.5

Result: The Average Specific Gravity of the soil sample(G) = 2.5

CONSISTENCY LIMITS

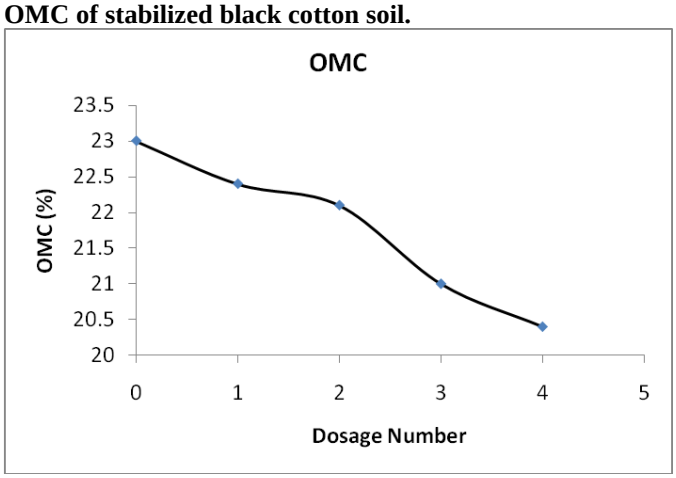
Dosage number	Enzyme dosage	Black cotton soil		
		Liquid limit (%)	Plastic limit (%)	Plasticity index
0	Un treated	61.4	34.0	27.4
1	200 ml/3.0 m^3	61.1	34.2	26.9
2	200 ml/2.5 m^3	60.7	34.4	26.5
3	200 ml/2.0 m^3	60.5	34.5	26.0
4	200 ml/1.5 m^3	60.4	34.3	26.1



COMPACTION:

Dosage number	Enzyme dosages	Standard compaction(light) OMC (%)
0	Un treated	23.0
1	200 ml/3.0 m^3	22.4
2	200 ml/2.5 m^3	22.1
3	200 ml/2.0 m^3	21.0
4	200 ml/1.5 m^3	20.4

OMC of stabilized black cotton soil.



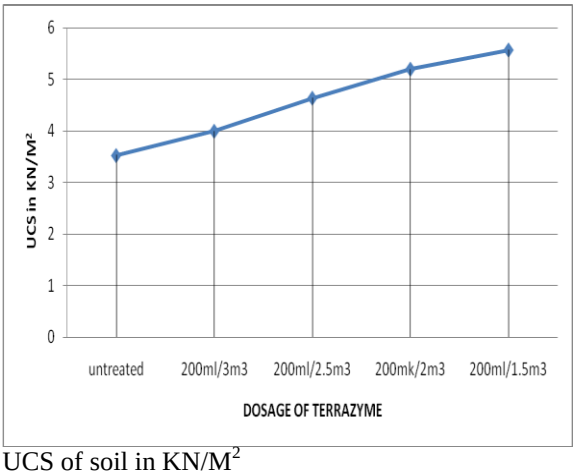
Variation on OMC with addition of Enzyme

Unconfined Compression Strength Test:

UCS of soil in KN/M^2

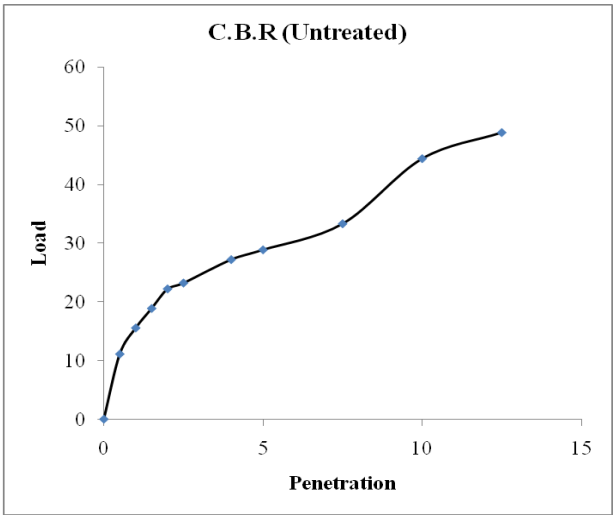
- Maximum Dry Density = 1.92g/cc
- Optimum Moisture Content= 11.66%

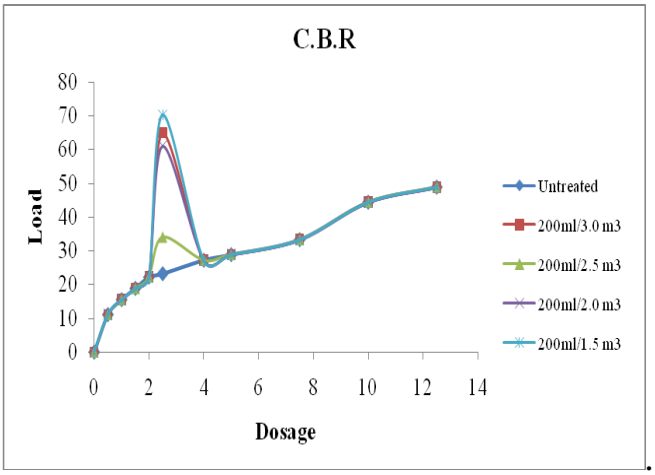
SL NO	DOSAGE	UCS in KN/M^2
1	Untreated	3.53
2	200ml/3m^3	4
3	200ml/2.5m^3	4.64
4	200ml/2m^3	5.20
5	200ml/1.5m^3	5.57



UCS of soil in KN/M^2

CALIFORNIA BEARING RATIO





Comparison of different dosage.

6. CONCLUSIONS

Based on the tests conducted the following conclusions have been drawn which are applicable only to materials used and test conditions adapted in this study.

1. Enzyme(TerraZyme) is found to be ineffective for consistency limits.
2. TerraZyme reduced the compaction effort and improved soil workability; where MDD increases and OMC decreases with addition of TerraZyme& Enzyme dosage of 200 ml/2 m^{3}showed maximum density 1.48 gm/cc with 23% OMC.
3. For a higher dosage of 200 ml/ 2 m^{3}of soil, the CBR value of BC soil increased by 274 percent.
4. The initial cost of using TerraZyme is high as compared to traditional approaches but the benefit of using TerraZyme is that the maintenance cost is zero, making this approach economically cost effective.

The conclusions presented above refer to a limited number of tests and enzyme stabilizers combinations tested in laboratory conditions and should not be extrapolated to other combinations of materials. These results should be validated with field experiments that involve the same combination of materials used in this study.

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