An Experimental Investigation on Soil Stabilization using Terrazyme

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Abstract. Soil is defined as minerals, gases, organic matter, liquid and organisms which together supports the life. Black cotton soil being clayey, deep, and impermeable, expands and becomes sticky during rainy season and contracts during the dry season engendering deep cracks. Black cotton soil being more expansive in nature, the shear strength is very less and thereby, lowering the bearing capacity too. To overcome the problem of low strength and bearing capacity of locally available soil and to stabilize soil for a longer life of buildings, improvisations have become a necessity. In this present study an effective technique is provided for ground improvement for soil stabilization using bio enzyme. Bio-enzyme namely Terrazyme is added to improvise Unconfined Compressive Strength (UCS) and California Bearing Ratio (CBR) value of soil, and these are further compared with virgin soil’s CBR and UCS values. The laboratory tests were conducted like California Bearing Ratio Test, Atterberg Consistency Limits and Compaction test on soil samples with differential Terrazyme. Percentages for redefining the properties. From the results, it is evident that Terrazyme has proven to be a most satisfying add-on that helps in improvising the supreme characteristics of the soil with the usage up to 0.2 - 0.4 ml. Being economical and eco-friendly makes it to stand out of all and has made it more preferable than other enzymes. The study concludes, the soil has become more stable to support a greater life span and more strengthened in the presence of Terrazyme. The experimental investigations and further discussions concerning Terrazyme usage can be more precisely contemplated in the paper.

1. Introduction

Soil stabilization is defined as alteration of one or more properties of soil, by chemical or mechanical means, to create improved material of soil which possesses the engineering desired properties. Soil is stabilized to prevent erosion and dust generation or to increase strength and durability or Irrespective to the purpose for stabilization, the desired result is the formation of a soil material or soil system that will remain in position under the conditions of design use the life of the
project. There exist various methods aimed at stabilization of soil like mechanical, chemical, cement, lime, bituminous, thermal, electrical stabilization, stabilization by grouting etc.

1.1 Basic principles of soil stabilization

a. Properties of stabilizing soil will be evaluated.
b. Deciding the lack of property of soil and choose economical and effective method of stabilization the soil.
c. Designing the stabilized when values are durability.

1.2 Need for soil stabilization

a. To provide a complete road network system to build in conventional method, Limited financial resources are used.
b. Use of locally available soil and appropriate stabilizing agent effectively.
c. Encouraging the use of wastages of industries in building low cost construction of roads.

Enzymes remain adsorbed by clay lattice, and then releases upon exchange through the metals cations. These makes a significant effect on clay lattice, which causes them to expand initially and then becomes tighten. Enzymes can also be captivated by colloids enabling them to be transported through the soil electrolyte media. Enzymes also helps release hydrogen ions from the soil bacteria, which results in pH gradients at the surfaces of particles of clay, which supports in breaking the structure of the clay. By definition, enzyme is an organic catalyst which helps in speeding up the chemical reaction or else it happen at the slower rate, and it doesn’t become the part of end product. To form an intermediate reactant, enzyme combine with the large organic molecule, which exchanges ions with the structure of clay, causing the cover-up effect and breaking down the lattice, which prevents the further loss of density and absorption of water.

The thickness of electrical double layer reduced by organic cation which allows enzyme treated soils to be more compacted and more tightly together. Enzyme supports in the development of cementitious compounds using the following reaction:

\[ \text{Enzyme} \quad \text{CSH.} \]

Terrazyme is ancation-reactive synthetic compound which forms a protective coating on oily layers of clay and particles of soil. Terrazyme reduces ion exchange and ion mobility. Simultaneously by eliminating the absorption of water the material becomes hydrophobic. The result obtained is a soil material which is less sensitive to moisture and more workable. And it can be compacted for a better particle-interlock state by traffic forces and equipment. Improved bearing capacity and higher internal friction leads to better particle interlock. It also means penetration of water is less and greater density. The reagent which tends to be active is always bonded to material particles and if reagent is in excess, additional water will facilitate deeper penetration into the soil horizon till the entire reagent has be absorbed. The basic effect of enzyme action in the structure of the soil can be summarized as, initially, the film of absorbed water is reduced or broken entirely. By purely mechanical method extension and shrinkage of colloidal soil constituents cannot be eliminated completely. However, by means of addition or removal of water, temperature effects with mechanical pressure, it is possible to vary the amount of water held in this manner. Such variations are attended by shrinkage or swelling. This provides an ideal point of operation for the enzyme.

In this Present study Black Cotton Soil (BCS) is considered with high plastic and high shrinkage and swelling properties. BCS is the crucial segment of this nature and road improvement industry knows the essential of it for asphalt work. So as to get the specified limits for plasticity index and liquid limit and other strength characteristics for airfields and roads as sub-base course, soil stabilization was tried using liquid stabilizer Terrazyme. By using of these materials economizes the overall cost and improves stability of sub-base for pavements. BCS were stabilized by using different Enzyme dosages and stabilized soil strength has been evaluated after curing
period of 0 day. The tests are carried out to determine consistency limits, CBR test of the soil specimens without and with stabilizer Bio-enzyme.

In present investigation attempt is made to stabilize BCS with Enzyme (Terrazyme). The consistency limit test, compaction and CBR tests are carried out in the laboratory for different mix proportions of Bio-enzyme with BCS.

2. Literature review
Faisal Ali et.al(2012) This research focused on three natural residual soil's to improvement these engineering properties and liquid chemicals are mixed with different proportions. Unconfined compressive strength (UCS), chemical performances as soil stabilizing agents and evaluate the effectiveness in moisture-density relationship (compaction). And can reduce plasticity and shrinkage by addition of liquid stabilizer by water molecules re-absorption elimination. On surface of clay platelets by ionizing and exchanging the water molecules it reduces optimum moisture content. Re-arranging the clay platelets by neutralizing it, maximum dry density increases and by increasing inter particles bonding increase compressive

C. Venkata Subramanian et.al(2011) Strength parameters were studied after the application of enzyme of four different dosages for period of two to three weeks with three different soils.

Penget al.(2011) On three soil's unconfined compression tests is conducted: soil l ,soil ll ,soil lll are named as fine-grained, slit loam and coarse grained textures respectively. With quick lime and an enzyme three soils were stabilized. In two different conditions upto 60 days the samples were cured; The two containers are air-dry and in sealed container. At room temperature samples were allowed to dry in air - dry curing where as in samples during moisture was pressered in curing time in sealed containers. In air - dry curing the enzyme are more effective for soil l and soil ll than quicklime. For soil lll air - dry curing is not effective and sealed curing for three soils too. The quick lime was more effective in sealed containers than enzyme in specimens which are not allowed to evaporate quick lime further hydration is promoted.

Shukla.M et al (2010) In order to assess its suitability we use organic, eco-friendly bio enzyme, non- toxic stabilizers that are treated with expansive soils are made experiments .when bio enzyme stabilizer is used in experiment it is effective and on wet side of OMC expansive soil of swelling decreases.

M B Mgangira et al (2009) Effects of enzyme with liquid chemicals as soil stabilizer. Plasticity index(Ip) of 35 soil and 7 PI of other. Tests- atterberg limits standard Proctor and unconfined compressive strength
- decrease in PI of both soil treatment are with enzyme based products
- Two products of soils are treated with enzyme based chemicals on UCS showed a mixed effect. UCS improvement is not consistence significant could be attributed for treatment.

A.U.Ravishankar et .al(2009) Terrazyme soil stabilizers product with lateritic soil conducted a comprehension study in dakshinakannada and udupi districts are used in pavements as base course doesn't satisfy the requirements it satisfies the atterberg limits until unless soil is blended with the sand at various proportion proportions to improve its properties. In unconfined compressive strength (UCC) soil and blended soil are effected of enzyme

R.A.Velasquez et.al (2006) In this study two types of soils are investigated and effectiveness of stabilization and mechanisms of enzyme products are also investigated using chemical analysis and resilient modulus testing.

Marasteanu et al. (2005 )In this study soils are stabilized using two enzymes and conducted two- axial and resilient modulus tests. Chemical analysis included for the enzyme are PH and metal concentrations.

Miburn & parsons(2004) Different tests conducted on soils which are stabilized with cement, lime, terrazyme and class c fly ash. Tests conducted are leach test, atterberg limits, freeze-thaw, wet-dry and the strength tests.
Alan F. Rauch et.al (2002) In this study, measure changes in the engineering properties standard soil tests are conducted. In this study three reference clays are used. And three representative liquid stabilizers. Each soil is characterized in terms of the compacted unit weight, Atterberg limits, undrained triaxial shear strength and 1D free swell potential.

In the present investigation attempt is made to stabilize BCS with enzyme (Terrazyme). Various experiments were carried out in the laboratory for finding the index and engineering properties of the different materials used during the study. California Bearing ratio (CBR), Consistency limits and compaction tests were conducted by using various percentages of terrazyme mixed with expansive soil for finding optimum percentage of terrazyme. The details of the tests are given below

3. Laboratory tests

3.1 Atterberg’s limit
Liquid limit (L.L) is defined as the water content, where soil tends to behave as liquid. Plastic limit (P.L) can be expressed as at which point soil ceases to be plastic in nature. Plasticity index is the measure of soil plasticity. It can be also expressed as difference between liquid and plastic limits.

![Fig.1 Liquid Limit test](image)

![Fig.2 Plastic Limit test](image)

**Table 1** Influence of terrazyme on plasticity characteristics

| S.No | Dosage of Terrazyme (ml) | Liquid Limit (%) | Plastic Limit (%) | Plasticity Index ($I_p$) |
|------|--------------------------|------------------|------------------|-------------------------|
| 1.   | 0                        | 68.00            | 25.00            | 43.00                   |
| 2.   | 0.2                      | 67.71            | 25.50            | 42.21                   |
| 3.   | 0.4                      | 67.52            | 26.22            | 41.30                   |
| 4.   | 0.6                      | 66.93            | 26.81            | 40.12                   |
| 5.   | 0.8                      | 66.26            | 27.15            | 39.11                   |
| 6.   | 1                        | 65.81            | 27.35            | 38.46                   |
| 7.   | 1.2                      | 65.45            | 27.56            | 37.89                   |
| 8.   | 1.4                      | 64.84            | 27.89            | 36.95                   |
| 9.   | 1.6                      | 64.22            | 28.12            | 36.10                   |
| 10.  | 1.8                      | 63.91            | 28.59            | 35.32                   |
| 11.  | 2                        | 63.15            | 28.96            | 34.19                   |
3.2 : Differential free swell index

Known as the increase in the volume of the soil which doesn't consist any external constraints, on submergence in the water.

Table 2 Variation of Differential free swell for soil samples treated with the various percentages with terrazyme

| S.No | Dosage of Terrazyme(ml) | Differential Free Swell Test (%) |
|------|-------------------------|---------------------------------|
| 1.   | 0                       | 140                             |
| 2.   | 0.2                     | 136                             |
| 3.   | 0.4                     | 127                             |
| 4.   | 0.6                     | 118                             |
| 5.   | 0.8                     | 107                             |
| 6.   | 1                       | 98                              |
| 7.   | 1.2                     | 86                              |
| 8.   | 1.4                     | 79                              |
| 9.   | 1.6                     | 66                              |
| 10.  | 1.8                     | 62                              |
| 11.  | 2                       | 57                              |

3.3 Compaction test

It is conducted to reduce the space of voids in the soil sample and also to understand the different compaction characteristics for various types of soils.

Fig.3 Compaction Test


**Table 3** Variation of compaction parameters for BCS treated with various percent of Terrazyme

| S.No | Dosage of Terrazyme (ml) | Dry Density (kN/m³) |
|------|--------------------------|---------------------|
| 1.   | 0                        | 15.82               |
| 2.   | 0.2                      | 18.1                |
| 3.   | 0.4                      | 20.4                |
| 4.   | 0.6                      | 22.7                |
| 5.   | 0                        | 22.9                |
| 6.   | 1                        | 21.1                |
| 7.   | 1.2                      | 20.3                |
| 8.   | 1.4                      | 17.6                |
| 9.   | 1.6                      | 16.9                |
| 10.  | 1.8                      | 15.0                |
| 11.  | 2                        | 14.2                |

3.4 *California Bearing Ratio Test*

Also known as CBR, defined as ratio of the force per unit area.

![Fig.4 California Bearing Ratio Test](image)

4 *Results and discussions*

Atterberg limits like liquid and plastic limits were found in the laboratory tests for the expansive Black cotton soil and conducted tests on BCS with addition of terrazyme, i.e; 0.2%, 0.4%, 0.6%, 0.8%, 1%, 1.2%, 1.4%, 1.6%, 1.8%, 2% by adding the percentages of terrazyme.

Water content significantly affects the designing properties of soil. From the present study the maximum water content occurred at the BCS is doesn’t reacted with terrazyme. By changing the percentages of Terrzyme the water content is gradually decreases. In the present study, at 25 blows the water content is 63% as per Fig.5.
In present study, content of terrazyme increases water content where plastic limit is increased gradually. The water content occured at BCS is not treated with the terrazyme.

In the present study, minimum plasticity is occured when the BCS is not reacted with the terrazyme. Defined as range of the content of water at which soil tends to behaves plastically. By adding terrazyme more in percentage, plasticity index increases gradually as shown in the figure 7.
Variation in the free swell index at various percentages of terrazyme as represented in figure 8. In this figure we can observe that free swelling index is 140% of parent soil without adding terrazyme. After the addition of terrazyme from 0.2% - 2%, free swell index decreases gradually.

After completion of compaction test on BCS with and without addition of terrazyme in various percentages, we can observe the changes in Maximum Dry Density (MDD). MDD for parent soil is 18.2KN/m³ respectively. But increase in percentage terrazyme, MDD changes gradually.
Samples are prepared and tested as per IS code procedure to find out the CBR value. We can observe that compressive strength of the samples increases gradually. At 2ml of terrazyme sample showing a maximum value. The curve from the Fig.9 showing the various occurs. The CBR values are gradually increases when BCS is treated with terrazyme.

Fig. 9 – MDD for various percentage of terrazyme

Fig. 10 Penetration of plunger vs load for various percentage of terrazyme
5. Conclusions
- Addition of terrazyme in the soil increases the percentage of coarser particles and reduce in the clay content and also reduces the liquid and plastic limit of the undefined soil. This liquid and plastic limit decreases which are irrespective to percentage of terrazyme used in the soil.
- Terrazyme is a non-corrosive, natural, non-toxic and biodegradable liquid. It is eco-friendly and does not pose any harm to the user.
- Usage of terrazyme increases strength of soil which is proved by the increase in CBR and UCS values.
- Terrazyme also reduces the void spaces in the soil and thus, increase in the copaction and the density soil.
- Consistency limits and the optimum content of moisture soil is decreased due to action of terrazyme.
- By decreasing the soil permeability terrazyme makes soil water resistance.

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