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Soil Stabilization Using Terrazyme

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Abstract-*The most important aspect of any project is its cost, performance, durability and time. As the methods used conventionally were very uneconomical and time consuming, there is an urgent need for development of new techniques which enhances the geotechnical properties of soil.*

The Bio Enzyme has emerged as a material which drastically improves the properties of soil, is eco-friendly and is economical in long run. In the present study, the virgin soil was mixed with various dosages of Terrazyme with different durations and had shown significant improvement in index properties of soil for e.g. Specific gravity, Optimum Moisture Content and Maximum Dry Density, and California Bearing Ratio (C.B.R.) (soaked). On the basis of experimental results the optimum dosage of Terrazyme was obtained. As the enzyme is an organic liquid, it is biodegradable in nature and it does not have any harmful effect on environment. Bio enzyme reduces the voids between the particles of soil and minimizes the amount of absorbed water in the soil so that compaction caused by enzymes can be maximum.

Keywords: *Soil stabilization; Bio enzyme; Biodegradable; Terrazyme; Specific gravity; California bearing ratio(C.B.R.).*

I.INTRODUCTION

A large part of central India and a portion of South India are covered with Black Cotton soils. These soils are residual deposits formed from basalt or trap rocks. Black cotton soils are clays of high plasticity. They contain essentially the clay mineral montmorillonite, which is the most unstable clay mineral, thus the soils have high shrinkage and swelling characteristics. The shearing strength of the soil is extremely low; it is highly compressible and has very low bearing capacity. It is very difficult to work with this soil, as do not posses sufficient strength to support the loads imposed upon them either during construction or during the service life of the structure. For better performance of structures built on such soils, the performance characteristics of such soils need to be improved.

The poor engineering performance of such soils has forced Engineers to attempt to improve the engineering properties of poor quality soils. There are various methods that could be used to improve the performance of poor quality soils. These methods range from replacing it with a good quality soil to methods that involve complex chemical process. The choice of a particular method depends mainly on the type of soil to be improved, its characteristics and the type and degree of improvement desired in a particular application.

Stabilizers can be divided into various categories, namely (a) traditional stabilizers-hydrated lime, Portland cement, and fly ash, (b) byproduct stabilizers-cement kiln dust, lime kiln dust, and other forms of byproduct lime and (c) nontraditional stabilizers-sulfonated oils, potassium compounds, ammonium chloride, enzymes, polymers, and so on. Nontraditional additives can be grouped into different categories: ionic, enzymes, lignosulfonates, salts, petroleum resins, polymers, sulfonated oils etc.

Recently bio-enzymes have emerged as a new chemical for soil stabilization. Bio-enzymes are chemical, organic, and liquid concentrated substances which are used to improve the stability of soil sub-grade for pavement structures. BioEnzyme is convenient to use, safe, effective and dramatically improves road quality.

1.1 Terrazyme as a stabilizer

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.

1.1.1 Mechanism of Stabilization-

In clay water mixture positively charged ions (cat-ions) are present around the clay particles, creating a film of water around the clay particle 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.
Terrazyme reacts with absorbed water layer of clay particle and causes reduction in the thickness around particle of soil, this result in the reduction of voids between the particles of soil, thereby giving soil particle a closer orientation with low compaction. This ultimately results in the decrease in swelling capacity of soil and it also reduces permeability of so.

$$H_2O + \text{Clay} \xrightarrow{\text{Enzyme}} \text{Calcium Silicate Hydrate}$$

1.1.2 Benefits of Terrazyme-As the strength and stiffness of the soil is increased by adding Terrazyme to soil maintenance cost gets reduced by 30 to 50 %.It decreases the plastic characteristic of soil. Pavement thickness is reduced by 30 to 50%. Construction time is reduced by 50 %. Terrazyme improves load bearing capacity of soil.

1.1.3 Properties of Terrazyme -It is an organic liquid formulated from vegetable extracts. Temperature shall be maintained at 55 degree centigrade otherwise Terrazyme loses its properties. This organic liquid is stable in nature and the risk of decay is negligible. It is required to dilute Terrazyme with water before application. The aroma of Terrazyme has no harmful effect. Table 1 shows the physical properties of Terrazyme.

Table 1: Properties of Terrazyme

Property	Value/Specification
Boiling point	212°F
Specific gravity	1 to 1.09
Ph value	4.3 to 4.6
Appearance	Brown colored liquid

II. EXPERIMENTAL RESULTS

The material which was used in the test is local soil from Ajwa Road, Vadodara (Gujarat) and Terrazyme (bio enzyme). To find out the suitability of Terrazyme on soil laboratory test were performed. The Terrazyme was obtained by Avijeet agencies, Ahmedabad (Gujarat), India. The dosage of Terrazyme is decided on the basis of type of soil.

To study the variation of geotechnical properties of local soil we have taken 2.0m^3 / 200ml and 1.5m^3 / 200ml. The prefatory tests were performed on the local soil with and without Terrazyme. The experimental analysis was carried out by taking dosage and curing time of three weeks into consideration.

The soil was crushed prior to tests and Terrazyme is mixed in different quantity for differ time period. Atterberg's limit test as per (IS: 2720, Part V-1985), Standard proctor test as per (IS: 2720, Part VII-1980), Grain size analysis (IS: 2720 Part IV -1985), Specific gravity analysis (IS: 2720, Part III -1980) ,California bearing ratio test (IS: 2720, Part XVI-1987) were performed on the soil in laboratory. According to 'Indian Standard Soil Classification System ', local soil was categorized as clay 'CI' type .Table 2 shows the geotechnical properties of local soil.

2.1 Geotechnical properties of the Black cotton soil

Table 2: Geotechnical properties of the soil

Sr. No	Property	Value
1	Specific gravity	2.57
2	Grain size distribution (%)	
	Gravel	0.0
	Sand	28.0
	Slit	46.5
	Clay	25.5
3	Consistency limits (%)	
	Liquid limit	44.73
	Plastic limit	23.96
	Plasticity index	20.76
	Shrinkage limit	9.18
4	Is classification	CI
5	Swelling index (%)	88
	Engineering properties	
6	Standard proctor	
	Max dry density(g/cc)	1.73
	OMC	13.5
7	Modified proctor	
	Max dry density (g/cc)	1.85
	OMC	11.1
8	CBR (Soaked)	4.36

2.2 Specific gravity (IS 2720-Part 3, 1980)

Specific gravity G is the ratio of unit weight of soil to unit weight of distilled water at 4 °centigrade. Specific gravity of soil is required for the calculation of unit weight, degree of saturation; water content etc .The unit weight is ultimately used for determining the settlement, pressure and stability problem. Table 3 shows the results of specific gravity of soil on application of Terrazyme and it states that the specific gravity increases on the application of Terrazyme but the increase is not that significant.

Table 3: Specific gravity

Soil	Specific gravity
Virgin soil	2.57
Virgin soil+1.5m³/200ml Terrazyme	2.59
Virgin soil+2m³/200ml Terrazyme	2.59

2.3 Consistency limit test (IS 2720 -Part 5, 1980 & Part 6, 1972)

Consistency limits are the boundary water content at which the soil undergoes from one state to another. Liquid limit test, plastic limit test and plasticity index falls under the category of consistency limit test. The shrinkage factors were also calculated. Table 4 shows the liquid limit, plastic limit and shrinkage limit. Figure 1 shows the comparison between the virgin and treated soil.

Table 4: Consistency limits (%)

Soil	Consistency limit (%)	Value
Virgin Soil	Liquid limit	44.72
	Plastic limit	23.96
	Plasticity index	20.76
	Shrinkage limit	9.18
Virgin soil+1.5m³/200ml Terrazyme	Liquid limit	39.39
	Plastic limit	19.12
	Plasticity index	20.27
	Shrinkage limit	11.17
Virgin soil+2m³/200ml Terrazyme	Liquid limit	38.21
	Plastic limit	17.11
	Plasticity index	21.10
	Shrinkage limit	12.3

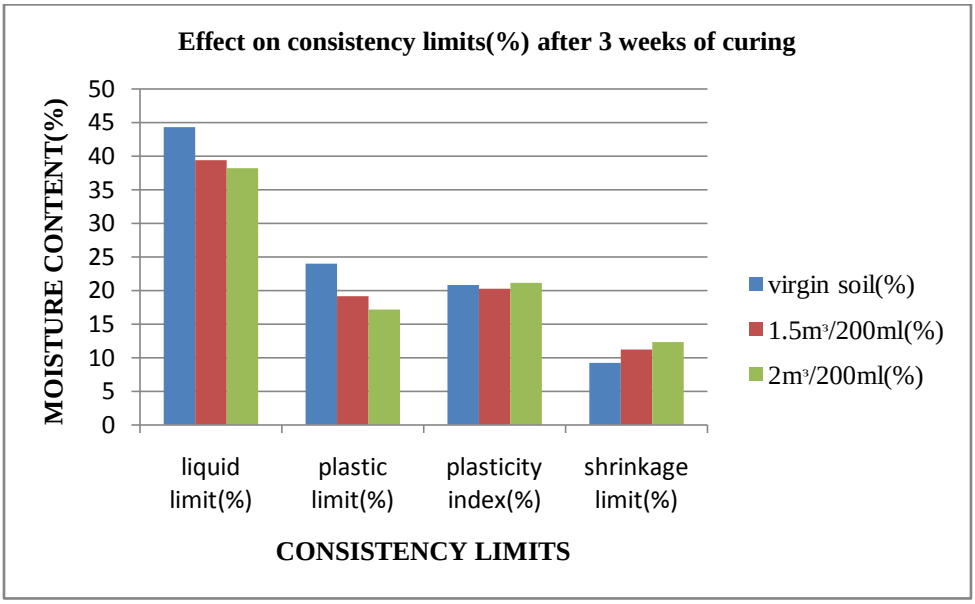

Fig 1: Comparison of consistency limits of virgin and treated soil

The figure shows that the liquid limit and plastic limit decreases and the shrinkage limit increases on the application of Terrazyme and the second dosage i.e. 2m³/200ml of Terrazyme decreases the plastic & liquid limit effectively.

2.4 Modified proctor test (IS: 2720- Part 8, 1983)

For determining the optimum moisture content and maximum dry density of the soil modified proctor test was conducted at laboratory .With the variable dosage of Terrazyme OMC and MDD were calculated for three weeks of curing. The effect of different dosage of Terrazyme on OMC and MDD of soil is shown in Table 5 and it states that the MDD increases and the OMC decreases on application of Terrazyme and the second dosage i.e. 2m³/200ml of Terrazyme increases MDD and decreases OMC effectively.

Table 5: Modified proctor test

Soil	MDD (g/cc)	OMC (%)
Virgin soil	1.89	11.1
Virgin soil+1.5m³/200ml Terrazyme	1.92	10.5
Virgin soil+2m³/200ml Terrazyme	1.96	10.3

2.5 California bearing ratio (C.B.R) (IS: 2720-Part 16, 1987)

The ratio expressed in percentage of force per unit area required to penetrate a soil mass with a circular plunger of 50 mm diameter at the rate of 1.25 mm/min to that required for corresponding penetration in a standard material. The ratio is usually determined for penetration of 2.5 and 5 mm. Here we took 2.5 mm penetration ratio as the C.B.R.

California bearing ratio test was done for soaked conditions. The test was performed by taking different dosages of Terrazyme i.e. (2.0m³/200ml), (1.5m³/200ml).Table 6 shows the effect of Terrazyme on the CBR (soaked) value of soil sample.

Table 6: Soaked C.B.R. (%)

Soil	Soaked C.B.R (%)
Virgin soil	4.36
Virgin soil+1.5m³/200ml Terrazyme	7.58
Virgin soil+2m³/200ml Terrazyme	11.07

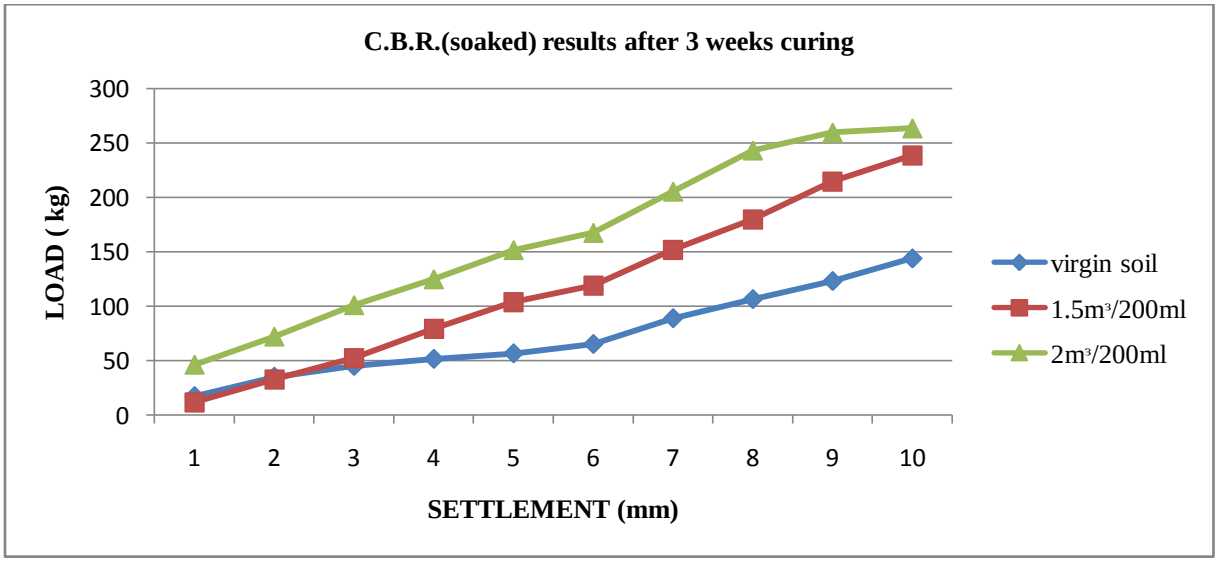

Fig 2: Comparison of soaked C.B.R. of the virgin and treated soil

The figure 2 shows that the C.B.R. Value of the soil increases on the application of Terrazyme and the second dosage i.e. $2m^3$/200ml of Terrazyme increases C.B.R. value effectively.

2.6 Free swell index (IS: 2720-part 40, 1977)

The potential of a soil to swell is termed as free swell index of a soil, which might need further detailed investigation regarding swelling and swelling pressures under different field conditions. Table 7 shows the swelling index of the soil after curing of three weeks and it states that the swelling index of the soil decreases on application of Terrazyme and the second dosage i.e $2m^3$/200ml of Terrazyme decreases the swelling index effectively.

Table 7: Free swell index (%)

Soil	Swelling index (%)
Virgin soil	88.8
Virgin soil+1.5m^3 /200ml Terrazyme	44
Virgin soil+2m^3/200ml Terrazyme	39

III. CONCLUSION

- Bio Enzymes are non poisonous, organic and biodegradable in nature. The product formed after the application of Terrazyme is bio degradable in nature and the effect is permanent.
- The treated soil has attained a hydrophobic nature which can be seen in the Atterberg's limits readings for the treated soil.
- The free swell index of the soil is reduced by about 50%.
- The shrinkage limit of the soil increases as the liquid limit of the soil decreases.
- The maximum dry density of the soil increases and the optimum moisture content of the soil decreases because the Terrazyme removes the water and air present in the soil and forms a cementing bond between soil particles.
- The second dosage of enzyme i.e. $2m^3$/200ml is the optimum one because the consistency limits are reduced and the soaked CBR increased after curing period of three weeks.
- It increases the value of C.B.R. by increasing the strength of the soil and as a result the thickness of the pavement, sub-base, base layers of the flexible pavement are reduced and thereby reducing the cost of material required.
- 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 soil should be cohesive for the experiment to be performed.

IV. FUTURE SCOPE

- Other bio enzymes and their effect on soil can be studied.
- Terrazyme effect on the soil with varying dosage and in varying stabilizing duration.
- Further tests can be performed for permeability, direct shear test and dynamic behavior of soil to improve the soil property.
- The effect of Terrazyme on the consolidation properties of the soil can be studied.

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