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An Experimental Study on Strength Enhancement of Locally Available Soil Using Terrazyme

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Abstract

This paper presents a work carried out for improving the strength characteristics of the sub grade soil. Most of the areas in Bangalore are found with Red soil and some Weak soil. The location of soil is chosen for this experiment is Kattigenahalli (Yelahanka). If the locally available soil could not be used for foundation work of roads due to low volume of its capacity, hence alternative techniques were developed for the use of conventional materials for different layers or stabilization method is applied. The main aim of this study is to effectively stabilize the soil by using Terrazyme. Enzymes are extracts from vegetables and which posses high value of strength when mixed with soil. Hence the soil is treated with different dosages of Terrazyme 200ml/3m^3, 200ml/2.5m^3 and 200ml/2m^3 of soil. The treated soil is conducted with UCS test for 0, 7, 15, and 30 days of curing at OMC, at dry side of OMC and at Wet side of OMC.From the obtained UCS results the optimum content of additive dosage is determined for all the three conditions of OMC. It is noted that the values of Compressive strength of treated soil is effectively increased for all dosages when compared with normal untreated soil.

Keywords:*Terrazyme, locally available soil, Sub grade and UCS.*

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Introduction

In developing city like Bangalore growth of population rate will increase day by day, which simultaneously leads to increase in growth of vehicle population, for this construction of road required with locally available soil only. Red soils, otherwise called as lateritic soils, are extensively used for road construction. Most of the areas in Bangalore are found with Red soil and some Weak soil. The location of soil is chosen for this experiment is Kattigenahalli (Yelahanka). If the locally available soil could not be used for foundation work of roads due to low volume of its capacity, hence alternative techniques were developed for the use of conventional materials for different layers or stabilization methods are adopted. Foundation ventures, for example, expressways, railroads, and so on requires soil material in enormous amount. At the point when road constructed on virgin soil, it require a more prominent thickness of asphalt and a huge amount of construction materials. In this way, there is a need of adoption of new techniques to decrease the construction cost while keeping up the adequate quality. Stabilization of soil is one of the systems to improve the nature of the sub grade

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soil and to lessen the construction cost. In different hands, ordinary materials like concrete, lime, synthetics and so on for adjustment of sub grade soil are expensive. Concrete adjustment now days aren't ideal as a result of the expanding cost of concrete and ecological concerns identified with its creation. An economically feasible solution for achieving these objectives is the use of enzyme soil stabilization.

Application of soil stabilization:
Following are the uses of soil stabilization

- Reduction in the penetrability through soils.
- It improves the bearing quality of soils foundation.
- It raises the soils shear capacity.
- It improves the sturdiness of soils under extreme dampness and stress conditions.
- It builds up the normal soils for the development of landing strips and streets.
- It controls the evaluating of soils and aggregate in development of sub base and base of airfields and highways.

Objectives
The objectives of current study is

- To determine the Engineering properties of Soil.
- To calculate the dosage levels of Terrazyme based on obtained OMC and MDD.
- To determine the strength performance of given soil by stabilizing with terrazyme at all the dosages at dry side and wet side of OMC.
- Comparison of unconfined compression test values for untreated soil with stabilized soil, with varying percentage of terrazyme dosage.

Materials

General
The sample was collected from a construction site in Kattigenahalli (Yelahanka). The sample was collected at 1.5m depth and amount of sample taken to the laboratory is 100kg.

Terrazyme

Terrazyme is delivered by figuring of vegetable concentrates, it is a characteristic, non harmful, non destructive and non inflammable fluid. These natural compounds come as fluid. Chemicals are flawlessly solvent in water, and it's earthy colored in shading with the smell of molasses. Smell of this catalyst has no impact. Neither covers nor gloves are required during working. Terrazyme is extraordinarily planned to change the designing properties of soil. They require weakening in water before application. When terrazyme is blended in with soil by including water, soil changes its building properties and it's rely on kind of soil and measurements of compound. [3]

Physical and chemical composition of Terrazyme. [10]

Item	DZ-1X	EarthZyme	TerraZyme
Water	—	21.06%	>50%

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Alcohols, C12–C16, ethoxylated	—	—	<30%
Fermented vegetable extract	—	—	<20%
Nonionic surfactants	—	55%	—
Polysaccharides	—	2%	—
Oligosaccharides	—	3%	—
Disaccharides	—	5%	—
Monosaccharide	—	8%	—
Lactic acid	—	3.5%	—
Potassium as the chloride	—	1.2%	—
Aluminum as the sulphate	—	0.04%	—
Magnesium as the sulphate	—	1.2%	—
Total	**—**	**100%**	**—**
Specific gravity	1.0	1.0 to 1.1	1.0 to 1.1
pH (neat)[1]	4.5	3 to 6	2.8 to 3.5
Boiling point	>100°C	>100°C	>100°C
Ultimate biodegradability	—	DOC[2] reduction >90% after 28 days	—
Composition	—	A blend of fermented carbohydrates, inorganic salts, and surfactants	—

Methodology and Experimental Investigation
Tests conducted to determine the physical properties of soil.

- Specific gravity -IS: 2720 ,Part– (3)1980
- Sieve analysis - IS: 2720, Part – (3)1985

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- Atterberg's limits - IS: 2720(Part –(4)1985
- Compaction - IS: 2720, Part – (5)1985
- UCS : IS: 2720, Part – (7)1979

The Gravel size fraction	15.4
The Sand size fraction	82.8
Silt and clay obtained	1
Specific gravity of BC Soil	2.41
Consistency limits (%)	
Liquid limit	44
Plastic limit	36
Plasticity index	8
Compaction test	
OMC(%)	14
MDD in g/cc	1.74
UCS in kN/m^2(IS-2720-PART-10-1991)	64.42

Table 1: Result of Untreated Soil

Dosage of Enzyme [13]
Terrazyme dosage added to the soil is depend upon the type of soil and it also added on the basis of research studies. There are 3 type of dosage are considered in this experiment they are 200ml/3m3 for D1, 200ml/2.5m3 for D2 and 200ml/2m3 for D3.

Terrazyme dosage calculation:
Dry density of soil obtained is= 1.74g/cc
Bulk density of soil (Yb)=Yd(1+w)
=1.74(1+0.14)
=1.98g/cc

- Dosage 1:

Add 200ml of terrazyme for 3m3 of soil sample = 3x1.98x1000 = 5490kg of soil
Therefore for 1 kg of sample = 200/5490 = 0.033ml of Terrazyme.

- Dosage 2:

Add 200ml of terrazyme for 2.5m3 of soil sample = 2.5x1.98x1000 = 4950kg of soil
Therefore for 1 kg of sample = 200/4950 = 0.040ml of Terrazyme.

- Dosage 3:

Add 200ml of terrazyme for 2m3 of soil sample = 2x1.98x1000 = 3960kg of soil
Therefore for 1 kg of sample = 200/3960 = 0.050ml of Terrazyme.

The enzyme treated soil is under gone for UCS tests. The UCS samples are kept for a curing period of 0, 7, 15, 30 days and the readings were noted on particular day of testing and analysed. The curing is done by covering samples with a air tight plastic covers and they are kept in a water filled air tight box and care taken that water should not reach the samples.

Dosage	**200ml/m^3 of soil**	**Ml /kg soil**
1	3.0	0.033

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2	2.5	0.040
3	2.0	0.050

Table-2: Terrazyme dosage

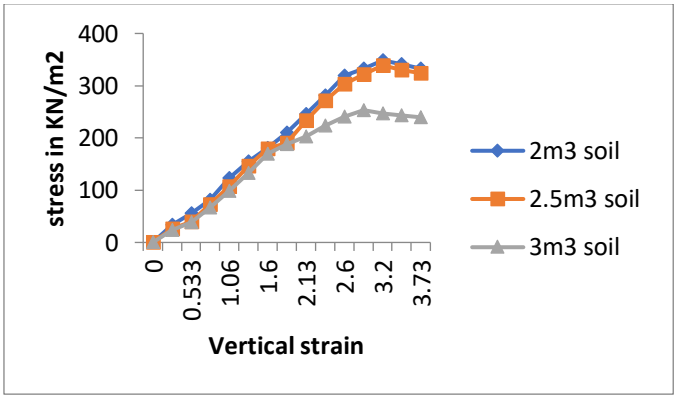
Consistency limits	**200ml/3.0m^3**	**200ml/2.5m^3**	**200ml/2.0m^3**
Liquid limit (%)	41.3	38.12	35.52
Plastic limit (%)	34	31.31	30.02
Plasticity index (%)	7.3	6.81	5.5

Table-3: Atterberg's limits to different dosages [3]

Dosage number	**Enzyme dosage**	**Standard compaction**	
		OMC(%)	**MDD(g/cc)**
1	200ml/2.0m^3	12	1.79
2	200ml/2.5m^3	12.7	1.86
3	200ml/3.0m^3	13.2	1.891

Table-4: Compaction to different type of dosages [3]

Test results of unconfined compression strength with various dosage of terrazyme and with various days of curing. [7]



Graph-1: variation of stress with strain in which soil treated with terrazyme dosage at 30 days curing.

DOSAGE	**D1**	**D2**	**D3**
DAYS	Max. COMPRESSIVE STRESS in kN/mm^2		
0	130.05	166.8	214.9
7	156.7	216.03	252.5
15	193.06	262.43	312.08
30	253.2	339.07	**348.44**

Table 5: Results of Max. compressive stress with respect to different dosages of terrazyme at various

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curing days at OMC condition.

Mechanism behind the change in soil properties[1]

Oneofthesignificantproblemsthathavefacedwhendiscussing softsoilsisadsorbedwateraroundthesoilparticles.Terrazyme is capable of reducing or eliminating the thickness of the adsorbedwaterlayerpresentinthesoil. It can increase the cohesive property of the soil and compaction behavior of the soil. A schematic representation of the process is illustrated in below figures.

With the addition of a particular amount of terrazyme into the soil (negatively charged colloidal particles of fine-grained soil), a change in the adsorbed water layer surrounding the clay particles occurs. The adsorbed water contains metal ions with a positive charge such as sodium, potassium, aluminium, magnesium, etc. Primarily water molecules are dissociated into hydrogen ions (+) and hydroxyl ions (-), the former may again combine with water molecules to form hydronium ions, as shown in below figure1.The positive charges from hydronium ions (+) or hydroxyl ions (-) combine with positively chargedmetal ionspresentinadsorbedwater.Reductionintheelectriccharge of water molecules, pressure from negatively charged ions on positively charged metal ions in adsorbed water wereobserved due to the effect of Terrazyme addition. The metal ions are forced to move towards the free water from the adsorbed water layer and thereby break down of the electrostatic barrier occurs. The metal ions moved to the free water can be reduced or removed due to washing of/evaporation. This process will make the soil structure to a more friable matrix with an adsorbed water layer of thinner one.

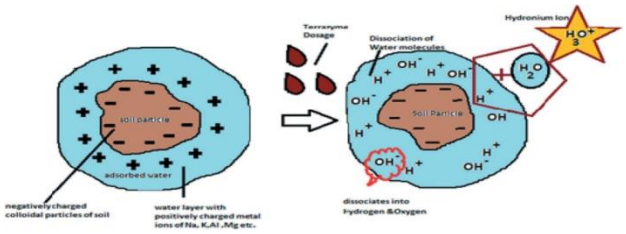

Figure 1: formation of hydronium ions in Terrazyme-soil mixture

Figure 2: Mechanismbehindtheeffectofterrazymeonthereductionofadsorbedwaterlayerthickness [8]

Effect of Terrazyme dosage on compaction characteristics of locally available soil [2]

From the compaction test of untreated soil 14% optimum moisture content and 1.744g/cc maximum dry density is obtained. To determine the effect of Terrazyme dosage, from compaction curve 3 points were selected that gave 3 different values of dry density. Thus dry density values corresponding to 95% MDD obtained with respect to OMC.

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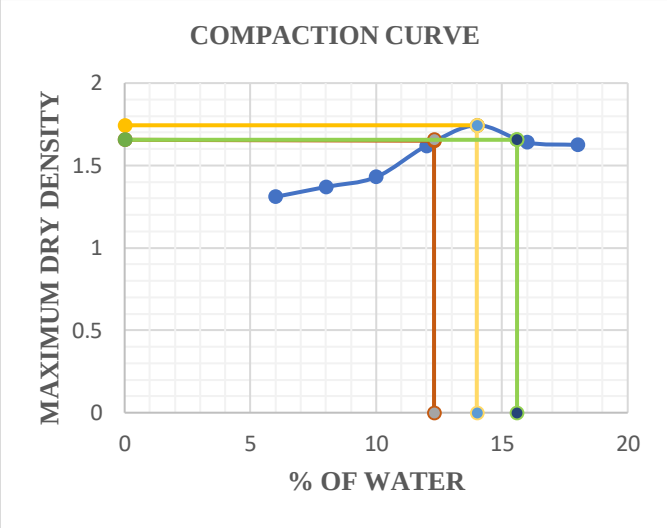
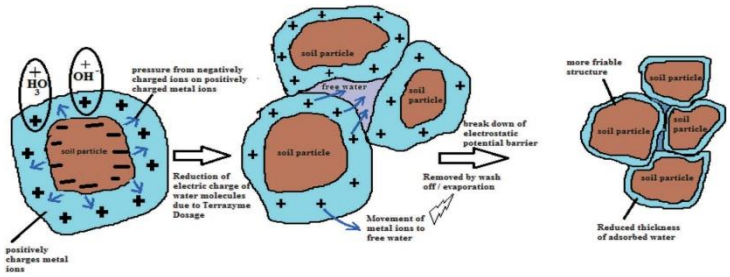


Graph-2: Compaction curve



From the graph, 2 different OMC is obtained with respect to dry density. The dry density obtained from the graph is **1.656g/cc** and dry side OMC and wet side OMC obtained is **12.3%** and **15.6%** respectively. UCS characteristics were studied by adding 3 levels of terrazyme dosage designated as D1,D2,D3 corresponding to dry density obtained on dry side OMC and wet side OMC as shown in above graph for soil without terrazyme. The amount of terrazyme dosage to be added is calculated for both dry and wet side of OMC.

Dosage	200ml/m3 of soil	Ml/kg of soil
1	3.0	0.035
2	2.5	0.043
3	2	0.053

Table 6: Terrazyme dosage for dry side OMC

Dosage	200ml/m3 of soil	Ml/kg of soil
1	3.0	0.034
2	2.5	0.041
3	2	0.052

Table 7: Terrazyme dosage for wet side OMC

Test results of unconfined compression strength with various dosage of terrazyme and with various days of curing(dry side OMC)

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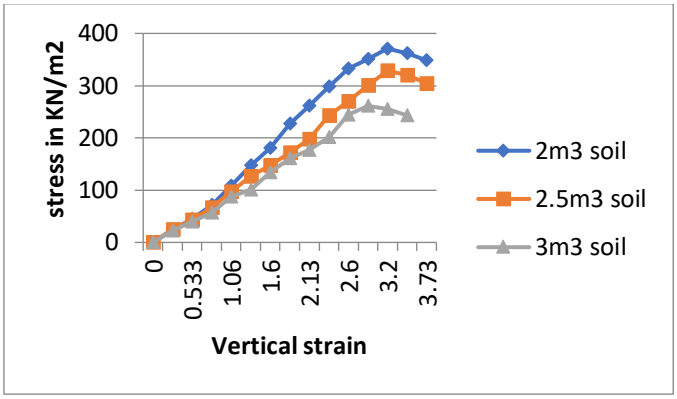
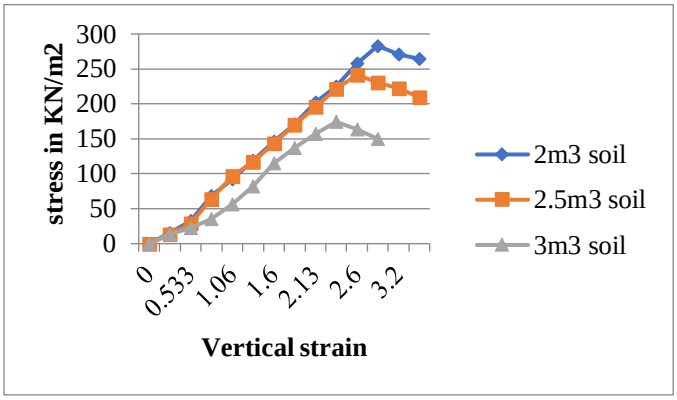


Graph-3: Variation of stress with strain for terrazyme treated soil for (dry side OMC) At 15 Days of Curing

DOSAGE	D1	D2	D3
DAYS	Max. COMPRESSIVE STRESS in KN/m^2		
0	203.98	240.33	280.01
7	218.5	273.74	314.43
15	261.35	328.51	**370.96**
30	295.51	348.08	363.77

Table-8: Results of Max. compressive stress with respect to different dosages of terrazyme at various curing days at DRY side of OMC

Test results of unconfined compression strength with various dosage of terrazyme and with various days of curing(wet side OMC)



Graph-4: Variation of stress with strain for terrazyme treated soil for (wet side OMC) at 15 Days of Curing

DOSAGE	D1	D2	D3

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DAYS	Max. COMPRESSIVE STRESS in KN/mm^2		
0	105.39	143.02	197.86
7	141.01	192	234.88
15	174.19	241.55	**283.04**
30	178.99	269.32	279.02

Table-9: Results of Max. compressive stress with respect to different dosages of terrazyme at various curing days at Wet side of OMC.

Results And Discussions

- The result obtained for specific gravity of soil is = 2.41
- The max dry density and OMC are obtained from compaction tests are respectively 1.74g/cc and 14%.
- The values of LL, PL, PI are obtained is 44%, 36% and 8 respectively.
- UCS value of untreated soil is =64.42KN/m2.

Dosage	Days of curing	Max.COMPRESSIVE STRESS in KN/m^2
untreated	0	64.42
D3(at OMC)	30	348.44
D3(dry side OMC)	15	**370.96**
D3(wet side OMC)	15	283.04

Table 10: Comparison of UCS values for untreated soil with treated soil

Discussion

Terrazyme is treated with soil with three different dosage say D1, D2, D3 and with curing period of 0, 7, 15 and 30 days. In this present study different geotechnical tests were conducted on virgin soil and enzymatic soil. By treating locally available soil with Terrazyme there is a significant improvement in consistency limits, compaction test, and unconfined compressive strength of soil.

The values of LL PL and PI of untreated soil are 44, 36 and 8 respectively. When soil stabilized with D3 dosage of terrazyme it reduces to LL-35.52, PL-30.02, PI-5.5. UCS value of untreated soil is 64.42KN/m2, in which it increases to 348.44KN/m2 for D3 dosage (dry side OMC) at 30 days curing.

Conclusion

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- The Plasticity characteristics of treated soil are found to be less compared to untreated soil.
- The overall maximum strength is achieved at 30 days of curing at OMC condition and 15 days of curing for other two condition of OMC.
- The UCS value of untreated soil is 64.42KN/m2, when treated with terrazyme of D3 dosage(dry side OMC) it increases to 370.96KN/m2 (82.63%) at 15 days of curing.
- Thus it clearly says maximum reduction in thickness of adsorbed layer happen when Terrazyme is added using water content slightly less than OMC

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