PERFORMANCE ANALYSIS ON EFFECT OF TERRAZYME ON SILTY CLAY SOIL

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***Abstract*: As interest of construction in india is expanding step by step. In emerging countries like India the primary need of any endeavor after execution measures is its affordable plausibility and functionality models The customary strategies are time taking and are not monetarily feasible. Hence we dealing with the other potential ways of fulfilling the presentation just as prudent standards. These proteins (terrazyme) have been demonstrated to fulfill the presentation just as affordable models. Also, above all the bio-compound are climate well disposed.**

The viability of bio chemical relies on the measure of compound which is to be included soil , sort of soil and relieving period. In our country around 15 lakh sq km which is 45.6% of absolute region comprises of silty clay (alluvial) soils. As the customary soil stabilizers like rock, sand and others are exhausting and becoming uneconomical step by step. It becomes essential to look towards for elective eco-obliging stabilizers as their substitute. as of late Bio-chemicals have arisen as efficient stabilizers for soil adjustment. One such sort of bio-chemical, Terazyme, has been utilized in the current work. Subsequent to treating with Terazyme the soil showed huge improvement in strength. With relieving period, the strength is expanding. Little improvement in liquid and plastic breaking point esteems with treatment of Terazyme compound.

INTRODUCTION

GENERAL

Soil improvement by mechanical or substance implies is generally embraced. To settle soils for further developing strength and sturdiness, various compound added substances, both inorganic and natural, have additionally been utilized. As of late Bio-Enzymes have arisen as another substance for soil adjustment. Bio-Enzymes are synthetic, natural, and fluid concentrated substances which are utilized to work on the strength of soil sub-base of asphalt structures. A protein is by definition a natural impetus that speed up compound response, that in any case would occur whatsoever gentle rate, without turning into a piece of the final result. Since the compounds don't turns into the piece of final result and are not devoured by the response, a tiny measure of bio-chemical is needed for soil adjustment. They are natural particles that catalyze unmistakable substance responses assuming conditions are helpful for the response they work with. For a catalyst to be dynamic in a soil, it should have versatility to reach at the response site. The pore liquid accessible in the dirt mass gives means to portability of the atoms of bio-compound, the particular soil science gives the response site, and time is required for the protein to diffuse to the response site. A catalyst would remain dynamic in a soil until there are no more responses to catalyze. Chemicals would be relied upon to be very soil explicit. Every protein is explicitly customized to advance a compound response inside or between different atoms. The actual compounds are unaltered by these responses. They fill in as a host for different particles, significantly speeding up the pace of typical substance and actual responses. The chemical permits soil materials to turn out to be all the more effectively wet and all the more thickly compacted. They likewise work on the substance holding between soil particles and making a more long-lasting design that is more impervious to enduring, water infiltration and mileage.

RIEF HISTORY OF THE AREA UNDER INVESTIGATION

Patan is a town and a nagar panchayat in Jabalpur area in the Indian territory of Madhya Pradesh. Patan is 30 km from Jabalpur on State Highway 37A which interfaces Damoh to Jabalpur. The dirt example is gathered from the River bank of hiren waterway .Hiran River is a stream in Madhya Pradesh and has a height of 329 meters .the avg yearly railfall of patan town is 110cm .the majority of the downpour occure in rainstorm months.

Temperatures remain commonly high reliably, with the pre-summer quite a while of April to early July having typical step by step temperatures of around 40C. During the tempest there are ordinary, significant storms and rainstorms. The chilly climate seemingly forever of November to February are delicate and magnificent, with typical temperatures going from 4-15C and with practically no dampness. TERRAZYME STABILIZATION

Extensive research has been conducted studying the application of traditional stabilization additives such as lime, cement and fly ash (Santoni et al. 2001).However, engineering research studying non-traditional stabilization additives such as enzymes are less documented. The U. S. army conducted soil stabilization by use of additives as early as the 1940‟s (Fine and Remington 1972) in the construction of airfields for heavy bombers. The US Army conducted extensive research on soil stabilization for roads and airfields. Field Manual 5-410 Chapter 9 (1997) is a detailed chapter on the design, analysis and application of soil stabilization techniques.

Soil stabilization techniques for civilian uses are currently a common practice with applications for roads and foundation performance improvement. According to Andromalos et al. (2000) soil mixing was first developed in the United States in the 1950‟s (Liver et al. 1954). In the late 1960 and early 1970s the Swedish used a mixed in place lime stabilization process (Ryan et al. 1989). In their paper (Andromalos et. al. 2000) the authors presented the design, analysis and application procedures of soil mixing in liquefaction mitigation and various other geotechnical applications. Krizek, (1992) conducted a study to evaluate the benefits gained by incorporating base course material with either fiber reinforced soil cement or compactable recycled aggregate cement into pavement systems. In his paper the author presented the cost benefits analysis of soil stabilization and presented a design procedure for pavement base course improvements using his proposed techniques.

Santoni et. al., (2001) conducted a laboratory experiment to evaluate the stabilization of silty-sand (SM) materials with traditional and nontraditional chemical or liquid stabilizers. Their research focused on the load bearing capacity as the basis of performance characterization. They tested four types of enzymes and found that none of the enzymes tested improved the unconfined compressive strength of the soil under the dry or wet conditions. Write-Fox and Macfarlane (1993) studied the stabilization performance of two types of enzyme stabilizers in addition to the performance of an asphalt emulsion and lime additive product. The stabilizers were tested on a highly plastic fat clay material and were based on the unconfined compressive strength test. Their results indicated that the undrained shear strengths of the enzyme products were21% higher than the control specimens this suggested that the products in the concentrations used, added a stabilizing quality to the relatively dry specimens. When the specimens were immersed in distilled water, the enzyme products nearly or completely disintegrated by slaking. This indicated that the products tested may not offer waterproofing qualities, using the recommended dilutions.

OBJECTIVES OF THE STUDY

Following are the key objectives of present study:

- ✓ Laboratory investigation of terrazyme on the quality of alluvial and silty clay type of soil
- ✓ To find out the proper quantity of terrazyme to be used as stabilizing agent and the extent of stabilization of strength gain with different

SCOPE OF THE STUDY

To satisfy the above destinations, research center trials are done on soil settled with terranyme. Research center Experiments are performed to inspect the adequacy of terrazyme in settling the dirts. Different impacting boundaries like dose of chemical, restoring period are given due thought in assessing the viability. When the appropriateness of the terrazyme in further developing the strength attributes are set up, the ideal measurements of terrazyme for ideal strength improvement is shown up at.

LITERATURE REVIEW

Alluvial soil and silty clay is fine grained soil deposited by water flowing by floodplain or river bed. As alluvial soil is mostly immature and weak in profile, a pile or raft Foundation is needed. As the soil is porous and liquefaction can occur. Alluvial soil or silty clay becomes unstable when saturated due to the lack of aggregate Silty soil can be smooth to the touch and retains water longer because of its smaller particles. However, because of its tendency to retain moisture it is cold and drains poorly. This causes the silty soil to expand, pushing against a foundation and weakening it, making **it not ideal for support**. Increase (or) decrease of water content in the fine soil causes further deterioration of the foundation which necessitates repair process at a higher cost. The strength of the soil is improved by stabilization.

SOIL STABILIZATION

Soil stabilization a general term for any physical, chemical, mechanical, biological or combined method of changing a natural soil to meet an engineering purpose. In civil engineering, soil stabilization is a technique to refine and improve the engineering properties of soils. These properties include mechanical strength, permeability, compressibility, durability and plasticity It is required when the soil available for construction is not suitable for the intended purpose. In its broadest sense, stabilization includes compaction, preconsolidation, drainage and many other such processes. However, the term stabilization is generally restricted to the strength properties. A cementing material or a chemical is added to a natural soil for the purpose of stabilization. The decreasing availability and increasing cost of construction materials and uncertain economic climates force engineers to consider more economical methods. An obvious solution is to use locally available materials. However, all too often, these materials fall outside of required specifications.

APPLICATION OF SOIL STABILIZATION

The process of soil stabilization is useful in the following applications:-

- Increasing the unconfined compressive strength of soil
- Increasing the shear strength of sols
- Improving the durability under adverse moisture and stress conditions
- Improving the natural soils for the construction of bridge and dam
- Reducing the permeability of soils

Scope and objective of research work

There are majorly 4 types of bio-enzymes till date are Renolith, Permazyme, Fujibetonand Terazyme. In the present investigation an attempt is made to stabilize the black cotton soilwith bio Enzyme (Terazyme). Detailed laboratory tests were carried out to ascertain the benefits in terms of engineering properties**.**

(a) To evaluate physical properties of silty clay soil (alluvial soil).

(b)To determine the effects of adding enzyme to silty clay soil on its properties

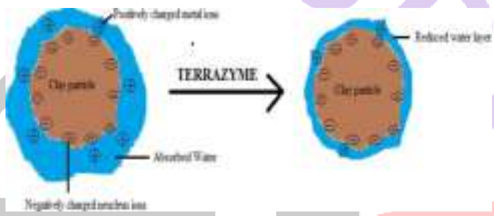
BIO-ENZYMATIC SOIL STABILIZATION

About Bio-enzyme

Terrazyme is non-toxic, non-corrosive, non-flammable natural material which is formulated from vegetable extracts. It is brown in color with smell of molasses and can be easily usedwithout the need of masks or gloves [4]. It is easily mixed with water and for optimal results should be diluted with optimum moisture content of that soil. Terrazyme act on the soil to reduce the voids between soil particles therefore minimizing the absorbed water in the soil and maximizing compaction. It reacts with the organic matter (humid matter) in the soil to form cementatious material. This decreases the swelling capacity of the soil particles and reduces permeability by increasing the chemical bonding between the soil particles making a permanent structure. This structure can withstand the effect of weather, wear and tear, weathering

Mechanism of Soil Stabilization by Bio-enzyme

Soil (clay) particle is surrounded by a negatively charged layer making the particle prone to combine with positive charge in order toneutralize. It is found that the absorbed water layer on soil contains sufficient positive metals like Na, K, Al, Mg etc becoming the reason of the bond between the negative clay particles and water molecules. Thus a significant water layer is created around the soil particles. In order to attain permanent compaction it is necessary to decreaseor eliminate this water layer. This is exactly what terrazyme does [5]. Terrazyme reduces the electric charge in water molecule, thus creating enough pressure on the positive metal ions to release in free water. This breaks the electrostatic potential barrier thereby reducing the absorbed water layer. Thus the soil particles come closer and attain greater compaction with lower compactive effort.



H2o + clay TerraZyme calcium Silicate Hydrates $\longrightarrow$

Literature on liquid chemical stabilizers

Isaac et al. (2003) had conducted laboratory study on five types of soil namely CL, OH, CH, CI SX.to improve the five soil properties they mixed with bio enzyme. They conducted CBR test for a pre fixing curing period. From the results it is clear that Terazyme is very effective, economical. most effective in case of silt content is more.

Velasquez et al. (2005) studied the enzyme mixing on soil stabilization.

they used two types of enzymes namely enzyme A and enzyme B. They conducted chemical analysis of enzyme Abefore the mechanical testing. After that they conducted resilient modulus and shear strength test on two soils which were stabilized with two different enzymes. Two types of soil are usednamed as soil 1 and soil 2. soil 1 mechanical properties are not affected by the enzyme A withenzyme B. The stiffness of soil 1 was increased. The resilient modulus of soil 2 increases by the application of both enzymes A and B. With time the enzyme activity on the soil stabilizationincreases. From the observations minimum four months of time required to get improvement in the shear strength of the soil

Shankar et al. (2009) studied the effect of Terazyme on locally available lateritic soil. The investigated lateritic soil was collected from udipi district region in Karnataka state. The lateritic soil is not full fill the requirements of sub base coarse.so to brought down the atterberglimits they mixed the lateritic soil with locally available river sand. The blended soil is mixed is stabilized by using Terazyme enzyme.

From the observations it has been concluded that if sand amount increases in blended soil the enzyme treated soil cbr value was decreasing. The enzyme is ineffective in improvingthe consistency limits of lateritic soil. Whereas Terazyme is effective in improving the engineering properties of the lateritic soil. For cohesion less soil Terazyme is not useful toimprove its properties.

Mgangira MB (2009) conducted laboratory results on the effect of enzyme based liquid chemicals as soil stabilizer. Soil 1 had plasticity index of 35 and the other had PI of 7. Tests –Atterberg limits, Standard proctor and unconfined compressive strength

1) Treatment with enzyme based products to lead a slight decrease in PI of both soil.

2) Enzyme based chemical treatment of two soils using the two products showed a mixed effect on the UCS. No consistence significant improvement in the UCS could be attributed totreatment.

Naagesh and Gandgadhara (2010) made experiments on an expansive soil treated with anorganic, non-toxic, eco-friendly bio-enzyme stabilizer in order to assess its suitability inreducing the swelling in expansive soils. They stated that reduction in void ratio of bio enzymetreated specimens with curing period significant reduction in swell properties. Theexperimental results indicate that the bio enzyme stabilizer used in the present investigation iseffective and the swelling of an expansive soil reduces on wet side of OMC. **Venkatasubramanian and Dhinakaran** (2011) three different soils with four differentdosages for 2 and 4 weeks of period after application of enzyme on its strength parameterswere studied. It is inferred from the results that addition of bio enzyme significantly improvesUCC and CBR values of selected samples.

Unconfined compressive strength: Among three different selected soils, UCC of soil 2has got higher value compare to two other soils. At the same time, the UCC of soil 1 falls in between values of soil 1 and 3 and soil 3 has got lowest UCC value. This higher rate of increaseobserved for all the soils treated with bio-enzyme with 4 weeks of duration. For all the soils, soil treated with dosage 3 for a period of 2 weeks' duration shows descending trend in CBR. For soil 3 except for dosage 1, for other three dosages of bio-enzyme there is descending trendin the rate of increase in CBR

Faisal A (2012) studied the three different types of residual soils. These three soils named as soil 1 soil 2 and soil 3. They conducted the tests as per the British institution. To brought downthe residual soil atterberg limits, the residual soil is mixed with liquid chemical. The liquid chemical was mixed to the residual soil in four different proportions. The liquid chemical mixed residual soil is tested after 1,7 and 14 days. It has been observed that the atterberg limitvalues is decreasing pattern. They conducted the proctor test. The liquid chemical soil showing that omc value decreases and dry density value is increasing. The unconfined compression strength is also increasing for liquid chemical mixed soil.

Greeshma et al. (2014) conducted experimental work on high liquid limit clay. The liquid limit clay behaviour was investigated by using Bio enzyme Terazyme additive. With treatmentof Terazyme the liquid limit is about 30% increase in the first two weeks. After that liquid limitis decreased slightly. However, shrinkage limit was decreased. The ucs value enhanced twelvetimes the original value.

Agarwal p and Kaur S (2014) studied the effect of Terazyme effect on expansive soil. They conducted unconfined strength test to determine the optimum dosage value. To determine the optimum value of dosage totally 5 dosages are mixed to the soil. After that they tested with curing period of 1day and 7 days. From experiments concluded that UCS strength value increases about 200 percent. They give the reason for working mechanism of Terazyme.

Rajoria V and Kaur S (2014) presented a research paper on soil stabilization by using enzymes. In this research paper four different types of enzymes were discussed. These enzymesare practised in different countries. The four enzymes are Renolith, Permazyme, Fujibeto and Terazyme. Renolith enzyme was developed in Germany country. Renolith is mixed with waterin a predetermined quantity. This water mixture was sprinkled over the soil. This type of enzyme is suitable in cement stabilized soil. By using Renolith enzyme cost reduction is reduced about 20 to 40 percent. This enzyme was helpful in arresting cracks

The second enzyme discussed is pemazyme.it is very useful in taw freeze types of soil.

It increases the compaction effort of clays and soils with silt content is more.

Fujibeton enzyme material was available in japan. Fujibeton is an organic polymer. Fujibeto soil mix is very easy to handle. This enzyme soil mixture requires less skilful workers, with minimum effort we can achieve maximum compaction effort.

The last enzyme discussed was Terazyme enzyme. Which was used in the present investigation to improve the properties of black cotton soil. The main supplier in India is avijeetagencies. The Terazyme is nontoxic eco-friendly material. The Terazyme soil mixture showingthe ucs Value increases about 100 times for a curing period of 30 days.

Thida AN and Than MS (2014) studied the strength behaviour on enzyme treated soils.

Soil samples are taken at about 3ft depth from Kyarnikan village in Patheingyi township and two places of ASEAN Highway. The soil examined belongs to CL as per the UNIFIED SOIL

CLASSIFICATION SYSTEM. Three enzyme dosages are selected as 0.5 litre, 1 litre and 1.5 litre per 33m3 of soil. The strength tests are conducted after the curing period of one week andfour weeks. When soils are stabilized with enzyme, UCS and CBR values are higher than thatof natural soil.

Khan TA and Taha MR (2015) In this experimental study, three types of bio enzymes from three different countries were used to improve University Kebangsaan Malaysia (UKM)soil. The effect of the three different bio enzymes on Atterberg limits, compaction curves, and unconfined compressive strength was studied. Controlled untreated and treated samples for twodosages at curing times up to three months were prepared and tested after completion of the curing period. From the experiment results, the mixed enzymes did not show any comprehensible improvement in the lab experiment program. that is, Atterberg limits, compaction, and unconfined compression tests. Little improvement, in some cases, could be related to the hypothesis that the enzymes did not produce any chemical change, and they onlyprevented moisture absorption to bring the particles closer.

Sen J and Singh JP (2015) In this study Black cotton soil with varying index properties havebeen tested for stabilization process. The black cotton soil is mixed with enzyme. The mixed stabilized soil was for a pre fixing period of 0 days, 14days, 21 days and 28 days for various enzyme dosages. The tests which were carried out are the California Bearing Ratio (CBR) testand Unconfined Compressive strength (UCS) test of the soil specimen. The test results indicatethat bio-enzyme stabilization improves the strength of BC soil up to great extent, which indicatethe bearing capacity and the resistance to deformation increases in stabilized soil.

Nandini DN and Kumar MT (2015) conducted experiments on red soil. The red soil is mixedwith Terazyme for three different dosages namely D1, D2, D3. They prepared the ucs sample with different moisture content and different density. They made samples for dry side of omc,omc and wet side of omc. From the results they concluded that there is reduction in strength with curing period

at omc density. There is significant improvement in ucs was observed at allcuring period corresponding to dry side of omc.
Venika S and Priyanka V (2015) put an effort to improve the local soil properties. For this they mixed the local soil with Terazyme for different dosages. After addition of enzyme they conducted experiments on specific gravity, atterberg limits, proctor test and cbr test for soakedand un soaked conditions. The results showing that there is no improvement in atterberg limitsand improvement was observed in cbr value.
Ramesh HN and Sagar SR (2015) studied the effect of Terazyme on black cotton soil and redearth soil separately. They conducted liquid limit, cbr. Unconfined compression strength, freeswell index, compressibility and compaction characteristics were studied. The tests were carried for both desiccators dried and air dried samples. The Terazyme showed improvement in air dried than the desiccator dried samples. From the experiments concluded that after 7 daysthere is a little increment in liquid limit of the soil. Free swell index decreases very rapidly. The ucs value of both soil material is increased very fast.

GENERAL FINDINGS BASED ON LITERATURE REVIEW

- Most researchers found that the application of TerraZyme on the soil improves the UCS to a large extent.
- Improves the soil structure sufficiently which results in cost savings up to 25%.
- Application of Terrazyme offer good result on an expansive soil.
- Decrease of plasticity index and permeability

METHODOLOGY AND EXPERIMENTAL INVESTIGATIONS

GENERAL

For the present research work, silty clay soil was collected from bank of hiren river located at patan,jabalpur district madhya Pradesh by method of distributed method of sampling silty clay soil was collected. The soil was taken at a depth of 1.5-meter for the research work. To know the natural moisture content soil was sealed in a polythene bag. Measures were taken for there is no further loss of moisture content. The collected soil was air dried for 1 day. The air dried soilwas pulverized using wooden hammer. The pulverized soil was passed through 4.75 mm sieve.Soil passed through 4.75mm sieve was taken in this research work

Terrazyme

It is a natural, non-toxic liquid, non-flammable, non-corrosive formulation, fermented from vegetable extracts. Literature confirms that Terrazyme improves the engineering qualities of the soil like CBR values and UCS values. This in turn also decreases the OMC and plasticity index of soil.

Figure 3.2 Terrazyme

TABLE 3.1 PROPERTIES OF TERRAZYME

IDENTITY	
Identity (As It Appears On Label)	N-Zyme
HAZARDOUS INGREDIENTS	
Hazardous Components	None
PHYSICAL/CHEMICAL CHARACTERISTICS	
Boiling Point	100 degree Celsius
Specific Gravity	1.05
Melting Point	Liquid
Evaporation Rate	Same as water
Solubility in Water	Complete
Appearance/ Odour	Brown liquid, Non-obnoxious
FIRE AND EXPLOSION HAZARD DATA	
Special Fire Fighting Procedures	None
Unusual Fire/Explosion Hazards	None
REACTIVITY DATA	
Unstable or Stable	Stable
Conditions to Avoid	Temperature of 45˚C, pH below 3.5 & above 9.5
HEALTH HAZARD	
Route(s) of entry	Skin: None Inhalation: None Ingestion: None
PRECAUTIONS FOR SAFE HANDLING AND USE	
Steps To Be Taken If Material Is Released or Spilled	Wash down with water
Waste Disposal Method	Flush into any sewage system
Procedures To Be Taken In Handling and Storing	Store at temperatures below 45˚C

CONTROL MEASURES	
Respiratory Protection	Not required
Working/Hygienic Practice	Normal good practices

DOSAGE OF ENZYME

Considering research studies done terrazyme the dosage depending upon types of the soil and it is in litres per/m^3 of soil. Most of the research studies have been done based on the dosage recommended by the suppliers. In this experimental investigation river bank (silty clay) soil was mixed with Terrazyme with different dosages as given in table 3.2.

Table:Dosage of terrazyme applied to soil sample

No	Dose	ml/m^3 of soil	ml/kg of soil
1	Dosage 1	200ml for 3cum	0.039
2	Dosage 2	400ml for 3.5cum	0.066
3	Dosage 3	600ml for 4cum	0.088

Figure 3.3 Dosage of Terrazyme

TESTING PROGRAMME

Tests were conducted to determine the Atterberg"s limit, Differential free swell. The details of testing programme for the basic properties of soil are tabulated in Table .

Table : Testing Programme for Basic Properties

S.No	Laboratory Tests	Complying Standards	Varying Parameters		Resulting Parameters
			Dosage of Terrazyme	Curing Period	
1	Grain Size Analysis	IS:2720 (PartIV) 1985	Untreated soil	0 Days	Coefficient of Uniformity and Coefficient of Curvature
2	Specific Gravity Test	IS:2720 (Part III/Sec 1) 1980	Untreated soil	0 Days	Specific Gravity
3	Atterberg"s Limit Test	IS:2720 (Part V) 1985	Untreated Soil Dosage 1 Dosage 2 Dosage 3	0 Days 20th Days	Shrinkage limit, Liquid Limit, Plastic Limit and Plasticity Index
4	Differential free swell	IS: 2720 (Part XL) 1977	Untreated soil Dosage 3	0 days 7th days	Increase in volume

ANALYSIS OF TEST RESULTS AND DISCUSSIONS

TESTS ON UNTREATED SOIL

Specific Gravity Test

For knowing the specific gravity, Specific gravity test was done with the reference of IS: 2720 (Part III/Sec I) 1980) by using pycnometer. Specific gravity of local soil was obtained to be **2.15**.

Grain Size Analysis

The sieve analysis was done to determine the relative proportions of different grain sizes which make up a given soil mass. The test was conducted as per IS: 2720 (Part IV) 1985.

About 500 gm of dry soil was subjected to a sieve analysis.

Observation Table

Table 4.1 Sieve Analysis

IS Sieve Size	Diameter of grain(mm)	Weight Retained (gm)	Cumulative Weight Retained (gm)	% Retained	% Finer
4.75	4.75	0	0	0	100
2.36	2.36	0	0	0	100
1.18	1.18	1.05	1.05	0.21	99.79
425	0.425	2.8	3.85	0.77	99.23
212	0.212	10.12	12.92	2.584	97.42
150	0.150	97.52	110.44	22.08	77.91
75	0.075	130	133.85	26	74

From the sieve analysis it was found that gravel was 0%, sand was 26% and fines (silt and clay fraction) were 74%.

Atterberg's Limit Test

This test was performed in the laboratory to determine the shrinkage limit ,liquid limit, plastic limit and plasticity index of the local soil as per IS: 2720 (Part V) 1985.

Shrinkage limit

Sr.no.	Determination No.	
1.	Wt. of container in gm,W_1	**13.46**
2.	Wt. of container + wet soil pat in gm,W_2	**81.32**
3.	Wt. of container + dry soil pat in gm,W_3	**60.44**
4.	Wt. of oven dry soil pat, W_0 in gm = (W_3-W_1)	**46.98**
5.	Wt. of water in gm = (W_2-W_3)	**20.88**
6.	Moisture content (%), W = (W_2-W_3)/ (W_3-W_1)*100	**44.44**
7.	Volume of wet soil pat (V), in cm	**45.279**
8.	Volume of dry soil pat (V_d) in cm^3 = (W_m)/ (G_m) By mercury displacement method a. Weight of displaced mercury in gm (W_m) Specific gravity of the mercury (G_m)	**31.43** **760.67** **12.86**
9.	Shrinkage limit (W_S) = [W – {(V-V_d) x /W_o}] x 100	**14.96%**

Shrinkage limit of virgin soil sample 14.96%

Liquid Limit

Observation Table

Table : Liquid Limit Test

No of Blows (N)	Water Content (%)
48	23.22
34	25.47
25	26.13
17	27.41

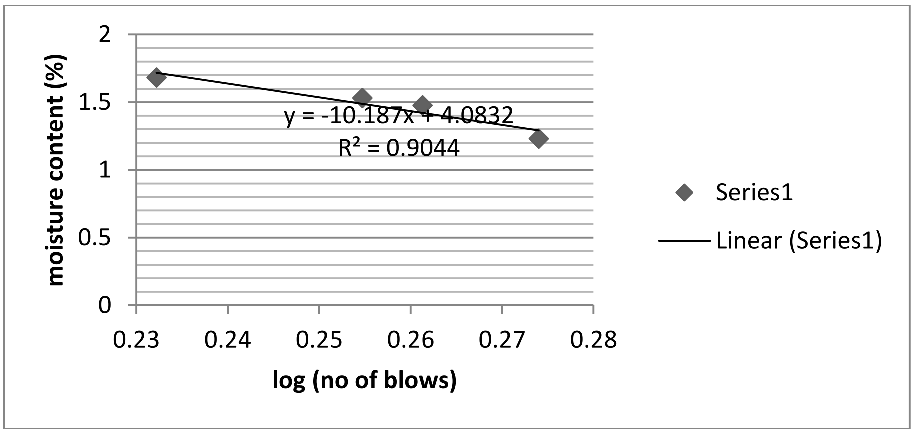


Figure: No of blows vs Moisture Content Graph

The Graph between number of blows (N) on a logarithmic scale and the water content (w) on a natural scale was plotted. The curve is known as flow curve. The water content corresponding to 25 number of blows is termed as Liquid limit. The Liquid Limit (LL) was found to be 26.13%.

Plastic Limit

The Plastic limit (PI) was found to be 20.57%.

Plasticity Index

Plasticity Index is the range of moisture content over which a soil exhibits plasticity. It is the numerical difference between the liquid limit and the plastic limit.

Plasticity Index (PI) = LL – PI PI = 26.13- 20.57
PI = 5.56
PI from a line 0.73(LL-20)=0.73(26.13-20)=4.47
Limit plot above A-line and LL-26.13 less than 35 ,PI is lying between 4-7 therefore dual symbol will be used
The Plasticity Index was found to be 5.56 and the soil was classified as low Plastic.

According to „Indian Standard Soil Classification System", the soil was classified as „CL-ML" type.

Differential Free Swell Test

Differential free swell test (DFS) test is conducted as per IS:2720(partXL) -1977
In this test free swell index of a soil sample is determined which helps to identify the Potential of a soil to swell.

Observation table

Determination no.	1	2
Mass of dry soil passing through 425μ sieve (gm)	10	10
Volume in water after 24 hours swell (Vd) (cc)	11	11
Volume in kerosene after 24 hours (Vk) (cc)	10	10
Free swell index (Vd-Vk)Vk × 100 (%)	10	10
Average (%)	**10**	

Average free swell index 10%

PERMEABILITY TEST

The permeability tests are conducted as per standard procedure (IS: 2720 (part 17)-1986, "Laboratory determination of permeability") for treated and virgin soil samples and the test results are tabulated in Table 3.11.

The permeability of untreated soil sample =2.36×10^{-7} cm/sec

TESTS ON ENZYME TREATED SOIL

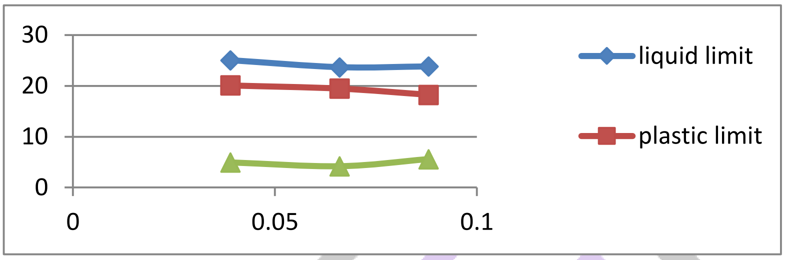
Atterberg's Limit Test

The liquid limit, plastic limit and plasticity index of enzyme treated soil with different dosage is tabulated in table.

Table 4.7 Liquid limit, Plastic limit and Plasticity index

Dose	Shrinkage limit(%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
Dosage 1 (0.039 ml/kg)	13.42	25.02	20.10	4.92
Dosage 2 (0.066 ml/kg)	12.93	23.65	19.47	4.18
Dosage 3 (0.088ml/kg)	12.56	23.80	18.23	5.57

Limits



Dosage of Terrazyme (ml/kg)

Figure: Variation of SL,LL, PL and PI with dosage of Terrazyme

SUMMARY OF RESULTS

The results obtained from the laboratory study are summarized in Table 4.11 and Table 4.12 below. Local soil was tested in the laboratory to find out the geotechnical properties like specific gravity, grain size distribution, consistency limits, compaction test,DFS, permeability, UCS and CBR.

Table 4.11 Geotechnical Properties of Untreated Soil

S.No	Property	Value
1	Specific Gravity	2.15
2	Grain Size Distribution Gravel (%) Sand (%) Fines (%) (Clay & Silt)	0% 26% 74%
3	Atterberg"s limit	
	shrimkage limit,(%)	14.96
	Liquid Limit (%)	26.13
	Plastic Limit (%)	20.57
	Plasticity Index (%)	5.56
4	IS Soil Classification	CL-ML
5	DFS	Free swell index= 10%

Table 4.12 Geotechnical Properties of Enzyme Treated Soil

S.No	Property	Dosage 1	Dosage 2	Dosage 3
1	Atterberg"s Limit			
	Shrinkage limit	13.42	12.93	12.56
	Liquid Limit (%)	25.02	23.65	23.80
	Plastic Limit (%)	20.10	19.47	18.23
	Plasticity Index (%)	4.92	4.18	5.57
2	DFS	Free swell index =0%		

1. CONSISTENCY LIMITS

As the level of Enzyme measurement increments from 0to 600ml/4m3 of soil there is decline in shrinkage limit from 14.96% to 12.56%. liquid limit as far as possible from 26.13% to 23.80% and slight reduction in plastic limit as far as possible from 20.57% to 18.23%.

2. Differential free swell

Initially the untreated soil has the free swell index of 10%. After curing the soil with terrazyme (with dosage 1)no volume expansion found Free swell index for terrazyme treated soil is found to be 0% suggested for artificially treated soils, to notice the change in strength these tests were directed.

CONCLUSIONS

- In the current review different geotechnical tests were performed on virgin soil and enzymatic soil. Bio-Enzymatic soil showed critical improvement in Consistency limits, ,DFS of nearby soil with various measurements. Term of treatment of Bio-Enzymatic soil assumed a fundamental part in progress of solidarity.
- Ideal portion of the Terrazyme was viewed as 400 ml/3.5m3 of soil, at which soil shows the impressive improvement in all the geotechnical properties.

SCOPE OF FUTURE WORK

This review can be broadened further as referenced beneath for understanding the conduct of enzymatic soil.

- The impact of Terrazyme on soil with various doses and in various relieving periods.
- The impacts of different kinds of Bio-Enzymes can be researched.
- Effect ofTerrazyme can be studied on blended soil.

More geotechnical boundaries e.g.direct shear box test, and dynamic conduct of soil can be studies to comprehend the change or improvement of geotechnical properties of soil.atigue analysis of the soil can be studied.A.U. Ravi Shankar and Harsha Kumar Rai (2009), "Bio-Enzyme Stabilized Lateritic Soil As A Highway Material"

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