

APPLICATION OF TERRAZYME (BIO-ENZYME) AS A SOIL STABILIZER

A major project report submitted in partial fulfillment of the requirements
For the degree of Bachelor in technology

Submitted by:

SWARNAPRAVA SAHOO (2021298028)

SK JAISH QUADRI (2021298023)

BISHWAJIT KAR (1901298067)

CHANDAN MALLIK (2021298012)

**Under the guidance of :
Asst. Prof Sanam Sarita Tripathy**

DEPARTMENT OF CIVIL ENGINEERING



**GANDHI INSTITUTE FOR TECHNOLOGY
BHUBANESWAR**



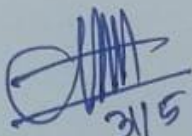
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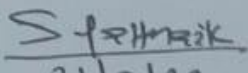
This is to certify that SWARNAPRAVA SAHOO (2021298028), SJ JAISH QUADRI (2021298023), BISHWAJIT KAR (1901298067), CHANDAN MALLIK (2021298012) of 8th semester of civil department, Gandhi Institute For Technology, BBSR, Odisha have satisfactorily completed the project report on “APPLICATION OF TERRAZYME (BIO-ENZYME) AS A SOIL STABILIZATION” in the partial fulfillment of requirement for the Bachelor Of Technology Degree in civil Engineering under Biju Patnaik University Of Technology, Rourkela, Odisha.


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DECLARATION

I hereby certify that the work which is being presented in the report entitled "**APPLICATION OF TERRAZYME (BIOENZYME IN A SOIL STABILIZER)**" in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in GANDHI INSTITUTE FOR TECHNOLOGY, Bhubaneswar is an authentic record of our own work carried out during the period from 2022 to 2023 under the supervision of Asst. Prof. Sanam Sarita Tripathy.

The matter embodied in this thesis has not been submitted by me for the award of any other degree of this or any other University/Institute.

This is to certify that above statement made by the student is correct to the best of our knowledge.

SWARNAPRAVA SAHOO (2021298028)

SK JAISH QUADRI (2021298023)

BISHWAJIT KAR (1901298067)

CHANDAN MALLIK (2021298012)

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SWARNAPRAVA SAHOO (2021298028)

SK JAISH QUADRI (2021298023)

BISHWAJIT KAR (1901298067)

CHANDAN MALLIK (2021298012)

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ABSTRACT

Soil stabilization is a mechanical or chemical alteration of one or more soil properties to create an improved soil material possessing the desired engineering properties. The aim of this article was to review bio enzyme-based soil stabilization techniques with an emphasis on Bio-enzymes production, mechanism of soil stabilization and future challenges, and opportunities of the sector. Soils are stabilized to increase strength and durability or to prevent erosion and dust generation. Cost-effective soil stabilization technology has been a fundamental part of any construction and is very important for economic growth in any country. In some cases, construction has been challenged due to the high cost of soil stabilization processes. Besides, methods of stabilizations using common stabilizing agents are getting costly. Currently, there is a growing interest to identify new and green technology to improve construction techniques and to expand the road network. Therefore, the search for new materials and improved techniques to process the local materials has received an increased focus. For developing countries, bio enzymes are now creating an opportunity to improve soil stability with tremendous effectiveness in the overall process of soil stabilization. In the world, bioenzymes have been used in different projects for several years and are generally proprietary products, often of patented formulation that needs intensive field tests. Currently, the use and production of bio enzymes is becoming the most promising key for the advancement of a country by saving time, energy, and finance. It also reduces environmental pollution due to carbon emission by the conventional stabilizers. Thus, a better understanding of this emerging technology is of utmost importance to exploit any improvement it can offer to soil stability. With little research and practice, it is possible to produce soil stabilizing bio enzymes using local raw materials. Due to this, production of low cost, easily and widely applicable, and environmentally friendly enzymatic formulations from locally available raw materials should be the interest of research and academic institutes of any country.

CHAPTER -1

1. INTRODUCTION

1.1 GENERAL

Soil stabilization is the permanent physical and chemical alteration of soils to enhance their physical properties. In its broadest senses, it includes compaction, pre consolidation, drainage, and many such processes. However, the term stabilization is generally restricted to the process Which alters the soil material itself for improvement of its properties. It is the collective term for any physical, chemical, or biological method, or combination of such methods employed to improve certain properties of natural soil to make it serve for intended engineering purposes. Improvements include increasing the dry unit weight, bearing capabilities, volume changes, the performance of insitu subsoil, sands, and other waste materials in order to strengthen road surfaces, and other geotechnical applications. It is required when the soil available for construction is not suitable for the intended purpose and mainly aimed at increasing resistance to softening by water through bonding the soil particles together, water proofing the particles, or combination of the two. Concept of stabilization is 5,000 years old and has been considered as old as construction has existed. Ancient Chinese, Romans, and Ices buildings and road ways which existed till today utilized different techniques of soil stabilization. Stabilized Earth roads were used in ancient Egypt and Mesopotamia and the Greeks and Romans used lime as a stabilizer. 'Us, building material dates back 5,000years when lime and clay were mixed and compacted to form bricks used in the construction of the pyramids and about2,000 years ago when the Romans used lime to improve thequality of their roads . Modern stabilization techniques are aimed at assuring adequate subgrade stability, especially for weaker soils. Soil stabilization is generally costly and requires huge investments. In some cases, construction has been hindered due to the high cost of soil stabilization techniques and depletion of stabilizing materials. Development of cost-effective materials and processes has been a crucial part of any construction for years. Hence, cost-effective road construction techniques are vital for economic growth in any country. As a result, there is an urgent need to identify new and cost-effective materials to

improve construction techniques and expand road networks. Recently, the search for new materials and improved techniques for processing the local materials has received an increased interest. In the past decades, a number of organic and inorganic chemical additives and different standard soil stabilizers like hydrated lime, Portland cement, and bitumen have been developed worldwide. However, more attention has recently been given to the use of bio enzymes as soil stabilizers

1.2 The specific objectives of the present study are as below

1. To carry out literature review for detail understanding of Bio enzyme as a soil stabilizer.
2. The behaviour of Bio-enzyme can be understood better, when a relative study is made. To facilitate this, Bio-enzyme and is tested under the same conditions of original soil specimens.
3. To study the influence of Shear strength of various different dosages 200 ml of (4m^3 , 3.5m^3 , 3m^3 , 2.5m^3 , 2m^3 , 1.5m^3 , & 1.0m^3) of Bio-enzyme replacement over original soil sample.
4. To study the influence of shear strength parameters of different layer reinforced soil with perfect dosages of Bio-enzyme.

1.3 ORGANISATION OF THE REPORT

- The present work has been organised into six chapters. Following is a brief outline of the report.
- In the second chapter, general overview of literatures from various journals and publication are overviewed and discussed.
- The third chapter presents the general overviews of various materials used in this study, the experimental program like mixing procedure, specification, detail of various tests and their procedure are discussed.
- The fourth chapter presents the various results and discussions of the study.
- The fifth chapter deals with the result of the study carried out, overall conclusions, and contribution are presented in the last chapter to bring out the outcome of the present work.
- The last chapter deals with the different References.

CHAPTER -2

2 LITERATURE REVIEW

Akash Priyadarshie and Niraj Kumar [1] (2019) investigate the local soil was mixed with Terrazyme with different dosages i.e. 3.5m³ per 200 ml, 3m³ per 200 ml, 2.5m³ per 200 ml. Due to use of bio-enzyme, production of low cost, easily and widely applicable, and environmentally friendly enzymatic formulations from locally available raw materials should be the interest of research and increase the shear strength.

K. Onyelowe and O. Ubachukwu [2] (2003) Have studied Enzymes as soil stabilizers have been used to improve the strength of subgrades due to low cost and relatively wide applicability compared to standard stabilizers.

Reddy Dr. K.V Krishna et al. [3] [2013] of Chilkur Balaji Institute of Technology, Hyderabad-75, AP, India; have discussed here about curing period of soil stabilization. According to their view, poor subgrade, especially clayey soils need stabilization for effective performance which developed definitely by compaction of curing period of works. By this paper they have determined the construction work on UCS with some admixture's and they also identified one important is that, the maturity period and curing was important quality of control parameter.

Agarwal Puneet et al. [4] [2014] of Manual Azad National Institute of Technology, Bhopal, have aimed to improve the performance of poor engineering black cotton soils which has high water content, low strength, and minimal bearing capacity by using one bio enzyme like Terrazyme. They found that, Terra-zyme treated black cotton soil shows significant increase UCS with longer period.

Prof. Jadhav et al. [5] [2016] explained about the stabilization of soil which helps to increase strength and durability or to prevent erosion and dust generation. In this case, they conducted a curing time on Atterberg's limit compaction, unconfined compression strength (UCS) and durability of black cotton soil. So, they have conducted that, improvement and stabilization of soils are widely used as an alternative to substitute the lacking of suitable material on site.

Rakaraddi P.G et al. [6] [2016] have discussed about the improvement in the properties of black cotton soil treated with terra-zyme stabilizer. The locally available soil sample were treated with a commercially available terra-zyme and treated soil were cured at different curing period 7, 14 & 21 days liquid limit value ,unconfined compressive strength (UCS) value increased significantly.

CHAPTER -3

3. MATERIALS & METHODS OF EXPERENTS

3.1 MATERIALS

3.1.1 SOIL

Locally available silty clay soil which was used for this project. This soil was collected from Mayurbhanj District.

The soil contains 83% particles finer than 75 micron. Fig 1 depicts the particle size distribution of this soil. The basic properties of soil or soil parameters obtained on conducting appropriate tests are as per IS: 2720 have been formulated in various parts. This part covers method of preparation of samples for the various laboratory tests covered in the standard.

The parameters of the soil obtained on conducting appropriate tests are given in the Table 3.1

3.1.2 TERRAZYME-BIO STABILIZER:

- Enzyme stabilization is commonly demonstrated by termites and ants in Latin America, Africa and Asia. Ant Saliva full of enzymes is used to build soil structure which is rock hard and meters high. These structures are known to stand firm despite heavy tropical rain seasons.
- Terrazyme is a nontoxic, natural, liquid enzyme that alters the physical and chemical features of soil. Soil enzymatic process improves the engineering qualities in the soil facilitating higher compaction densities and increasing the soil stability through closer bonding particles.
- Terra-zyme is basically a bio-enzymatic product has been used for the improvement of pavements.

- Terra-zyme is a liquid chemical used as a stabilizer in soil stabilization which can be easily mixed with water.
- Terra-zyme increases the durability of soil pavement and reduces the swelling properties of soil.
- The use of Terrazyme enhances weather resistance and improves load bearing capacity of soil
- Enzyme stabilization is commonly demonstrated by termites and ants in Latin America, Africa and Asia. Ant Saliva full of enzymes is used to build soil structure which is rock hard and meters high. These structures are known to stand firm despite heavy tropical rain seasons.
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- Terra-zyme is a liquid chemical used as a stabilizer in soil stabilization which can be easily mixed with water.
- Terra-zyme increases the durability of soil pavement and reduces the swelling properties of soil.
- The use of Terrazyme enhances weather resistance and improves load bearing capacity of soil.

3.1.3 PROPERTIES OF TERRAZYME:

- Terrazyme is an organic liquid formulated from vegetable extracts.
- Terrazyme is required 55degree centigrade temprature; otherwise it loose properties.
- This organic liquid is stable in nature and the risk of decay is negligible.
- It is required to dilute terra-zyme with water before application which has no harmful effect.
- Terrazyme required long air-dry curing period with very little amount of solution.

3.1.4 Dosages of Terra-zyme:

A dosage for expansive clayey soil was 200ml for bulk density of 1.98gm/cc.

So, Bulk density of soil= 1.98 gm/cc

For Dosages 1: 200ml for 5.0m³ of soil = $1.98 \times 5 \times 1000 = 9900\text{kg}$ of soil.

For 3kg of soil = $3 \times 0.022\text{ml} = 0.06\text{ml}$ enzyme.

3.1.5 WATER

Clean potable water as obtained from laboratory of Civil Engineering Department of GIFT Autonomous College was used for mixing and curing of soil specimen.

Table 3.1 PROPERTIES OF TERRAZYME

Identity	Enzyme
Hazardous component	None
Boiling point	212°F
Specific gravity	1-109
Melting point	Liquid
Evaporating rate	Same as water
Solubility in water	Complete
Appearance	Brown colour liquid

Table 3.3 Physical Properties of coarse aggregate

SL.NO	PARTICULARS	TEST RESULTS
1	Specific Gravity	2.6
2	Uniformity co-efficient	2.28
3	Coefficient curvature	1.11

3.2 EXPERIMENT PROGRAMME

3.2.(A) PREPARATION OF SOIL SMPLE

Different mix of Soil + Terrazyme solution with geocell & original soil sample obtained to conduct specific gravity test, coarse and fine grained analysis of soil, Liquid and Plastic limit of soil , Modified Proctor test of soil ,UCS test on standard mould of sample size 38mm diameter and 76mm height , Tri-axial test of soil sample of size 75 mm(diameter) & 150mm (height). The curing period for the UCS soil sample are 7, 14, 21 &28 days respectably.

3.2. (B) MIXING PROCEDURE

Proper quantity mixing of Terrazyme solution with soil should be ensured to get correct test results of the soil specimen strength. For original soil sample initially the oven dried soil is weighed for required quantity and poured into another mixing tray or mould which is completely dry. For mixing with Terrazyme, the above-explained procedure is followed. Terrazyme which is mixed with water and according to OMC add the solution to the soil. Different terrazyme dosages 200 ml of (4m³, 3.5m³, 3m³ 2.5m³, 2m³, 1.5m³, & 1.0m³) is mixed and tested.

3.2. (C) CURING PROCEDURE

After preparing the soil sample, sample was kept air tight container for 7, 14, 21 and 8 days. Maintain the moisture content properly.



Fig 3.3 Curing of soil sample for UCS test

3.2 TESTING OF SOIL SAMPLE

Various tests conducted on soil sample in order and briefly described.

3.2.1 SPECIFIC GRAVITY OF SOIL

Specific gravity of soil particle (G) is the ratio of a unit volume of soil solids to the mass of the same volume of gas-free distilled water at a stated temperature (27°C). It is an important parameter and is also used for determination of void ratio and particle size. The standardized detailed procedure for the determination of the specific gravity of soil solids is contained in Indian standard specification.

Standard Reference:

IS 2720 (Part III) – 1980 is the standard recommended to determine specific gravity of fine grained soils.

The specific gravity of solid particle can be determined in the laboratory using many methods that is pycnometer method, density bottle method, jar method etc.

Pycnometer method is used for coarse grained soil while density bottle method is used for fine grained soil. Density bottle method is used for present study.

Equation for specific gravity, G:

$$G = \frac{W_2 - W_1}{(W_2 - W_1) - (W_3 - W_4)}$$

Where, W1= weight of empty bottle

W2= weight of bottle + dry soil

W3= weight of bottle + soil + water

W4= weight of bottle + water

Specific gravity for different soil is not same, generally the general range in which the specific gravity of soil can be categorized as given in table:

Table 3.4 Specific gravity of different soil

Sand	2.63-2.67
Silt	2.65-2.7
Clay and Silt	2.67-2.9
Organic soil	<2

3.2.2 PARTICLE SIZE DISTRIBUTION

3.2.2 A) Sieve analysis of coarse grained soil

The soil contains 83% particles finer than 75 micron. Rest 184 gram of oven dried soil are taken for Sieve analysis by the help of sieve shaker machine. The different sieve size are 4.75mm, 2.36mm, 1.18mm, 0.600mm, 0.450mm, 0.212mm, 0.150mm, .075mm.

Standard Reference:

IS: 2720 (Part 4): 1985. Scope: To determine grain size of soil fraction passing through 4.75

mm IS sieve and retained on 75 micron IS Sieve.



Fig 3.4 Sieve shaker machine

3.2.2 (B) Grain size distribution of fine grained soil by hydrometer analysis

Hydrometer method is used to determine the particle size distribution of fine-grained soils passing 75 μ sieves. The hydrometer measures the specific gravity of the soil suspension at the centre of its bulb. The specific gravity depends upon the mass of solids present, which in turn depends upon the particle size. Hydrometer analysis is an indirect method of assessing the size of soil particle based on Stokes law which relates the velocity with which a spherical particle settles in a still liquid to the diameter of the particle. Hence the size of particle determined in this method is known as equivalent diameter. Hydrometer at any instant measures the relative density of soil suspension.

The amount of soil taken 50 gms of oven dried which is passing through 0.075mm.

Standard Reference:

IS: 2720 (Part 4): 1985. IS: 2720 (Part 4): 1985. Scope: To determine grain size of soils.

3.2.3 LIQUID LIMIT TEST

The liquid limit is the moisture content at which a soil ceases to be plastic. After receiving the soil sample it is dried in air or in oven. The soil passing 425 micron sieve is used in this test. It becomes semi-fluid and tends to flow like a liquid under an applied pressure. This limit is used for classification of soils for engineering purpose. The apparatus used for determining the liquid limit is *liquid limit device* i.e. Casagrande apparatus.

Standard Reference:

IS: 2720(Part 5)-1985-Methods of test for soils of determination of liquid and plastic limit.

Consistency of fine-grained soils may be defined as the relative ease with which a soil can be remolded. Consistency limits may be categorized into three limits called Atterberg limits. They are 1) Liquid limit 2) Plastic limit.

3.2.4 PLASTIC LIMIT TEST

The plastic limit is the lowest moisture content at which a soil can be deformed without cracking. It is the upper limit of moisture content for tillage operation for most crops, except rice. Tillage operations in soil at moisture content above the plastic limit result in smearing and puddling of the soil.

Standard Reference:

IS: 2720(Part 5)-1985 - Methods of test for soils of determination of liquid and plastic limit.

3.2.5 SWELLING INDEX TEST

The swell index test procedure is used to determine the general swelling characteristics of bentonite clay. The Swell Index test has not been demonstrated to have a proportional correlation to hydraulic properties, a high swell is considered by most to be a good indicator of bentonite quality.

Free Swell Index is the increase in volume of a soil, without any external constraints, on submergence in water.

Standard Reference:

IS 2720 (Part-40): 1977 “Method of test for soils Determination of Free swell Index of soils”.

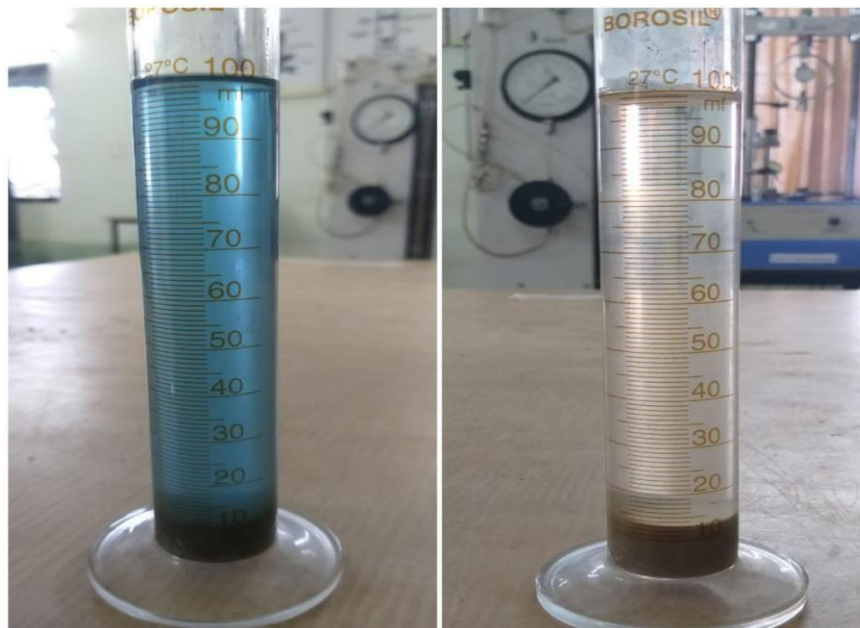
REPORTING OF RESULTS

Free swell index

$$= [V_d - V_k] / V_k \times 100\%$$

Where, V_d = volume of soil specimen read from the graduated cylinder containing distilled water.

V_k = volume of soil specimen read from the graduated cylinder containing kerosene.



Soil with kerosene

Soil with water

Fig 3.5 Swelling index test

3.2.6 MODIFIED PROCTOR TEST

Soil compaction is the process of increasing bulk density and reducing pore volume as a result of the applied pressure. It leads to destruction of larger pores, re-arrangement of solid particles and compression of air within the pore spaces in the soil.

In this modified proctor test generally preferred as the road construction work and easily determine the O.M.C and M.D.D of soil.

Standard Reference:

IS: 2720 (PART 8): 1983, to determine the water content-dry density relation of soil using heavy compaction.



Fig 3.6 Modified proctor test (Heavy compaction)



Fig 3.7 Thermostatically Controlled Ovens



Fig 3.8 Weighing machine

3.2.7 UNCONFINED COMPRESSION TEST

The Unconfined Compression Test is a laboratory test used to derive the Unconfined Compressive Strength (UCS) of a soil specimen. Unconfined Compressive Strength (UCS) stands for the maximum axial compressive stress that a specimen can bear under zero confining stress.

Standard Reference:

IS 2720(Part 10): 1991, determination of unconfined compression test.

3.2.7 A) Preparation of soil sample

The mould size of the USC test is 38mm diameter and 76mm long. The amount or the weight of soil which is passing through the 425 μm sieve, required to prepare one soil sample.

$$\begin{aligned}
 &= Y_d \times \text{vol. of mould} \\
 &= 1.685 \times \pi/4 \times d^2 \times h \\
 &= 1.685 \times \pi/4 \times 3.8^2 \times 7.6 = 146 \text{ gram}
 \end{aligned}$$

The amount of water required to add the soil sample = Weight of soil sample \times O.M.C

$$\begin{aligned}
 &= 146 \times 15.50 \% \\
 &= 21.9 \text{ gm. or } 21.9 \text{ ml}
 \end{aligned}$$

3.2.7 B) CALCULATIONS

Stress-strain values shall be follows:

- a) The axial strain, e , shall from the following relationship:

$$\epsilon = \frac{\Delta L}{L}$$

Where dL = the change in the specimen length as read from the strain dial indicator, and L = the initial length of the specimen.

- b) The average cross-sectional area, A , at a particular strain shall be determined from the following relationship:

$$A = \frac{A_0}{1 - e}$$

Where A_0 = the initial average cross-sectional are of the specimen.

- c) Compressive stress, shall be determined from the relationship:

$$\sigma_c = \frac{P}{A}$$



Fig 3.9 UCS Sample preparation



Fig 3.10 UCS Soil sample weight



Fig 3.11 UCS sample extractor



Fig 3.13 UCS Testing machine set up



Fig 3.144 UCS SAMPLE



1



2



3



4) Geocell failure pattern



5



Terrazyme failure pattern

Fig 3.15 UCS SAMPLE FAILURE PATTERN

r

CHAPTER – 4

RESULT AND DISSCUSION

This chapter deals with the presentation of test result, and discussion on shear strength, dry density and Triaxial test shear parameter development of original soil sample over reinforced soil and Terrazyme at different dosages 200 ML per (4, 3.5, 3, 2.5, 2, 1.5, ,1) and different curing period.

4.1 SPECIFIC GRAVITY OF SOIL

The test result of specific gravity is shown in table 4.1

Table-4.1 Specific gravity of soil

S.I No	Description	Trail-1	Trail-2	Trail-3
1	Wt. of dry Density bottle (W1)	33.33	33.33	33.33
2	wt. of dry Density bottle+ soil(W2)	43.30	43.20	43.00
3	Weight of dry soil taken $W_d = (w2 - w1)$ g.	10.00	9.95	10.00
4	Weight of density bottle + soil + water (W3)	89.00	88.56	88.93
5	Weight of pycnometer + water (W4)	82.70	82.29	82.56
6	Specific gravity corresponding to test temprature(G_s)	2.70	2.70	2.75
7	Specific gravity corresponding to 27p c (G).	2.70	2.80	2.80
8	Average specific gravity	2.76		

Specific gravity of soil is-2.76

4.2 PARTICLE SIZE DISTRIBUTION

4.2.1 Sieve analysis

The soil contains 83% particles finer than 75 micron. Rest 184 gram of oven dried soil are taken for Sieve analysis by the help of sieve shaker machine.

Table-4.2 Result of sieve analysis

Sl.No.	Sieve size (mm)	Weight of soil retained (gm.)	% weight retained	Cumulative % retained	% Finer
1	4.75	0	0	0	100
2	2.36	0	0	0	100
3	1.18	0	0	0	100
4	0.6	33	17.93	17.93	82.07
5	0.45	38.7	21.03	38.97	61.03
6	0.21	49.2	26.74	65.71	34.29
7	0.15	22.6	12.28	77.99	22.01
8	0.075	40.5	22.01	100	0

4.2.2 Hydrometer analysis

The test result of hydrometer analysis is shown in the following table 4.4

TABLE 4.4

Calculation of hydrometer											
	Time(min)	Temp.	Ct	Cd	Rh'	$Rh = Rh' + C_m - C_d + C_c$	He	Viscosity	Sp. Gravity	Diameter	% of finer
Observation-1	0.5	29	0.0004	1.003	1.004	1.0024	18.7	8.18	0.996	0.0729	6.19
Observation-2	1	29	0.0004	1.003	1.003	1.0014	19.1	8.18	0.996	0.0521	3.61
Observation-3	2	29	0.0004	1.003	1.021	1.0184	12.6	8.18	0.996	0.0299	47.46
Observation-4	4	29	0.0004	1.003	1.023	1.0214	11.5	8.18	0.996	0.0202	55.2
Observation-5	8	29	0.0004	1.003	1.021	1.0194	12.3	8.18	0.996	0.0148	50.04
Observation-6	15	29	0.0004	1.003	1.018	1.0164	13.4	8.18	0.996	0.0113	42.3
Observation-7	30	29	0.0004	1.003	1.016	1.0144	14.1	8.18	0.996	0.0082	37.15
Observation-8	60	29	0.0004	1.003	1.013	1.0109	15.5	8.18	0.996	0.0061	28.12
Observation-9	120	29	0.0004	1.003	1.012	1.0099	15.8	8.18	0.996	0.0043	25.54
Observation-10	240	29	0.0004	1.003	1.009	1.0074	16.8	8.18	0.996	0.0032	19.09
Observation-11	480	29	0.0004	1.003	1.008	1.0064	17.2	8.18	0.996	0.0023	16.51
Observation-12	720	29	0.0004	1.003	1.007	1.0054	17.6	8.18	0.996	0.0019	13.93
Observation-13	9	29	0.0004	1.003	1.006	1.0044	17.9	8.18	0.996	0.0168	11.35

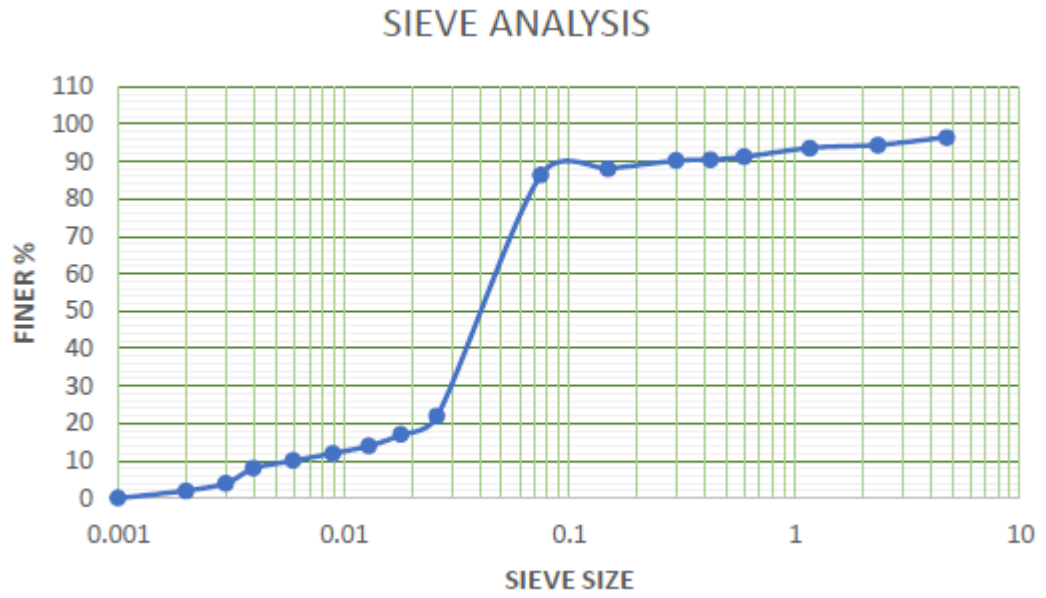


Fig 4.0.1 Grain size distribution

4.3 LIQUID LIMIT TEST

The test result of hydrometer analysis is shown in the following table 4.5

Table 4.5 liquid limit test

LIQUID LIMIT OF SOIL				
Sl no	Description	Trial-1	Trial-2	Trial-3
1	No of observation	1	2	3
2	No of blows	33	21	18
3	Moisture tin number	12	18	15
4	Wt. of moisture tin (gm.)	20	20	20
4	Wt. of wet soil+ moisture tin (gm.)	38	34	27
5	Wt. of dry soil + moisture tin (gm.)	32	29	24.7
7	Weight of dry soil (gm.)	12	9	4
8	Weight of water	6	5	2.3
9	moisture content in %	50	55.56	57.5

4.4 PLASTIC LIMIT TEST

The test result of hydrometer analysis is shown in the following table 4.6

Table 4.6 plastic limit test

PLASTIC LIMIT TEST					
Sl. No.	Determination No.	1	2	3	4
1	Watch glass No.	24	6	40	49
2	Wt. of watch glass+wet soil (gm.)	15	15	15	15
3	Wt. of watch glass+ dry soil (gm.)	13.75	13.95	14.02	14.03
4	Wt. of water (gm.)	1.25	1.05	0.98	0.97
5	Wt. of container (gm.)	10	10	10	10
6	Wt. of dry soil (gm.)	3.75	3.95	4.02	4.03
7	Moisture content %	33.3333	26.5823	24.3781	24.0695
8	Average	27			

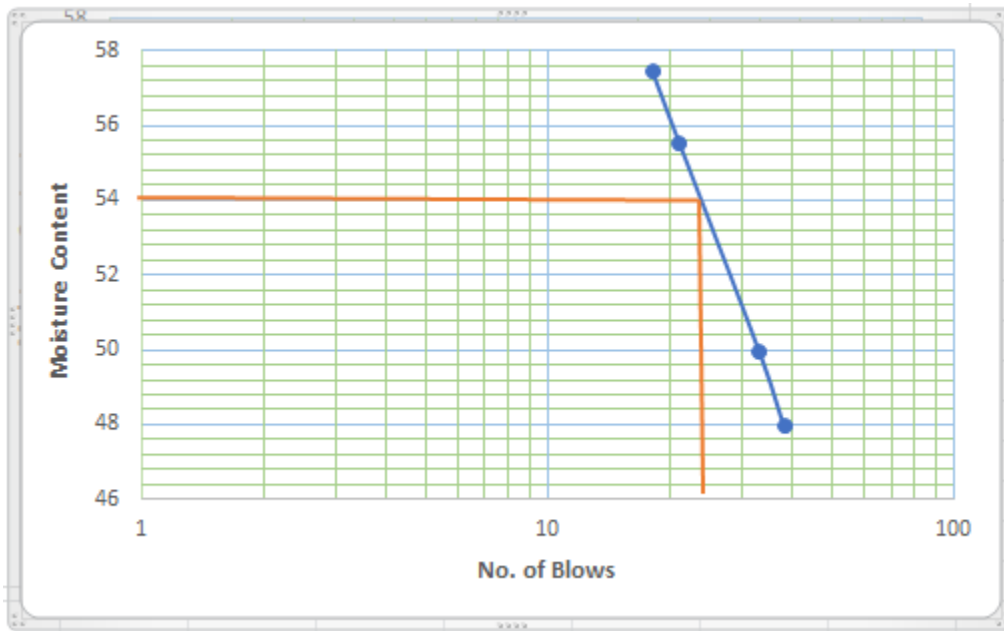


Fig 4.0.2 liquid limit graph

4.5 SWELLING INDEX TEST

REPORTING OF RESULTS

Free swell index

$$= [V_d - V_k] / V_k \times 100\%$$

$$= [13 - 10] / 10 \times 100\%$$

$$= 30\%$$

Where, V_d = volume of soil specimen read from the graduated cylinder containing distilled water.

V_k = volume of soil specimen read from the graduated cylinder containing kerosene.

4.6 MODIFIED PROCTOR TEST (COMPACTION TEST)

Modified compaction test is required due to heavy load is required in road construction. The table 4.5 is shown the result of compaction test or M.D.D and O.M.C of original soil sample.

4.6.1 Original soil test result

Table 4.7 compaction test result for original soil

Modified Proctor test											
WEIGHT OF EMPTY MOULD = 4595gm											
SL. No	Water % added	Wt. f mould +soil gms	Wt. of soil gms	Wt density gm./cc	MOISTURE DETERMINATION					Moisture content %	Dry density kN/m ³
					Container No.	Wt. of Container gms	Wt. of container + wet soil in gms	Wt. of container + dry soil gms	Wt. of water gms.		
1	6	6340	1745	1.745	5	15.39	50	47.03	2.97	9.39	15.95
2	8	6416	1821	1.821	6	15.53	50	46.42	3.58	11.6	16.32
3	10	6513	1918	1.918	7	16.33	50	45.81	4.19	14.2	16.79
4	12	6557	1962	1.962	8	15.84	50	45.18	4.82	16.4	16.85
5	14	6558	1963	1.963	9	16.04	50	44.74	5.26	18.3	16.59
6	16	6551	1956	1.956	10	15.79	50	44.17	5.83	20.5	16.23

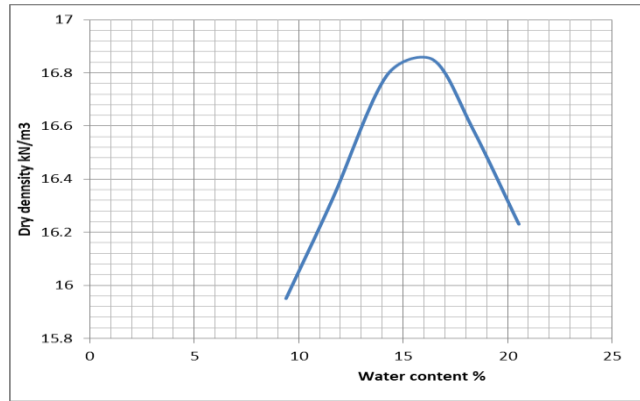


Fig 4.1 Water content and Dry Density relationship of original soil

Optimum Moisture Content (OMC) 15.50%

Maximum Dry Density (MDD) 16.52 kN/m³

4.6.1 A) Testing OF TERRAZYME mixed compaction test

As the study of different Literature Review, The different dosages of Terrazyme are taken

Different dosages (m ³)	Quantity (ml)
4 ,3.5,3,2.5,2,1.5,1	200



Fig 4.1.a) Terrazyme collected sample

4.6.2 Addition of 200ml Terrazyme at 4m³ soil.

Modified Proctor test									
WEIGHT OF EMPTY MOULD = 4595gm									
SL. No	Water % added	Wt. f mould +soil gms	Wt density gm/cc	MOISTURE DETERMINATION					
				Container No.	Wt. of Container gms	Wt. of container + wet soil in gms	Wt. of container + dry soil gms	Moisture content %	Dry density kN/m ³
1	6	6348	1.75	5	15.39	50	47.05	9.3207	16.04
2	8	6424	1.83	6	15.53	50	46.43	11.542	16.39
3	10	6521	1.93	7	16.33	50	45.84	14.097	16.88
4	12	6567	1.97	8	15.84	50	45.3	15.954	17
5	14	6568	1.97	9	16.04	50	44.77	18.204	16.6
6	16	6559	1.96	10	15.79	50	44.21	20.373	16.33

Table 4.7.1 Addition of 200ml Terrazyme at 4m³ soil

Optimum Moisture Content (OMC) 15.50%

Maximum Dry Density (MDD) 17.01Kn/m³

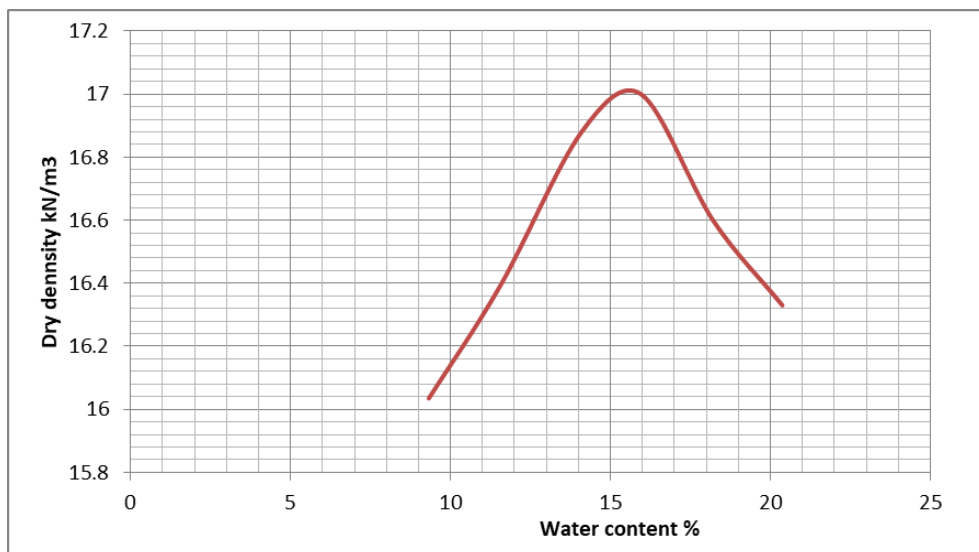


Fig 4.2 Water content and Dry Density relationship of 4m³ soil

Modified Proctor test											
WEIGHT OF EMPTY MOULD = 4595gm											
SL. No	Water % added	Wt. f mould +soil gms	Wt. of soil gms	Wt density gm./cc	MOISTURE DETERMINATION						
					Container No.	Wt. of Container gms	Wt. of container + wet soil in gms	Wt. of container + dry soil gms	Wt. of water gms.	Moisture content %	Dry density kN/m ³
1	6	6340	1745	1.745	5	15.39	50	48.6	1.4	6.07	16.45
2	8	6416	1821	1.821	6	15.53	50	48	2	7.82	16.89
3	10	6513	1918	1.918	7	16.33	50	46.23	3.77	12.6	17.06
4	12	6557	1962	1.962	8	15.84	50	45.63	4.37	14.7	17.11
5	14	6558	1963	1.963	9	16.04	50	45	5	17.3	16.74
6	16	6551	1956	1.956	10	15.79	50	44.62	5.38	18.7	16.44

Table 4.7.2 Addition of 200ml Terrazyme at 3.5m³ soil

Optimum Moisture Content (OMC) 14.22%

Maximum Dry Density (MDD) 17.11 kN/m³

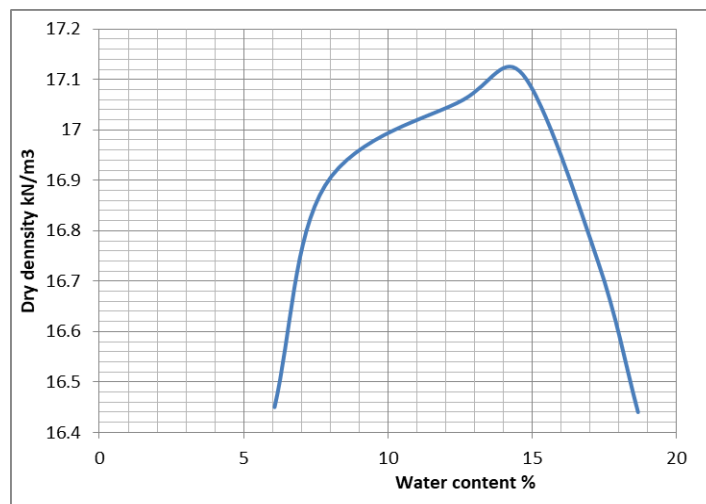


Fig 4.3 Water content and Dry Density relationship of 3.5 m³ soils

Table 4.7.3 Addition of 200ml Terrazyme at 3m³ soil.

Modified Proctor test											
WEIGHT OF EMPTY MOULD = 4595gm											
SL. No	Water % added	Wt. f mould +soil gms	Wt. of soil gms	Wt density gm/cc	MOISTURE DETERMINATION						
					Container No.	Wt. of Container gms	Wt. of container + wet soil in gms	Wt. of container + dry soil gms	Wt. of water gms.	Moisture content %	Dry density gm/cc
1	6	6340	1745	1.745	5	15.39	50	48.6	1.4	4.2	16.74
2	8	6416	1821	1.821	6	15.53	50	48	2	6.2	17.25
3	10	6513	1918	1.918	7	16.33	50	47.5	2.5	8	17.76
4	12	6557	1962	1.962	8	15.84	50	46.9	3.1	10	17.84
5	14	6558	1963	1.963	9	16.04	50	46.2	3.8	13	17.43
6	16	6551	1956	1.956	10	15.79	50	45.8	4.2	14	17.16

Optimum Moisture Content (OMC) 9.8%

Maximum Dry Density (MDD) 17.87 kN/m³

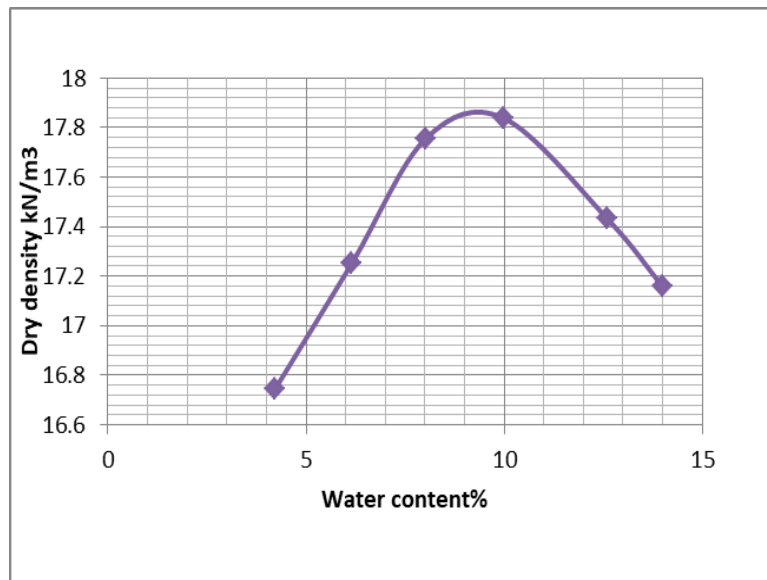


Fig 4.4 Water content and Dry Density relationship of 3 m³ soils

Table 4.7.4 Addition of 200ml Terrazyme at 2.5 m³ soil.

Modified Proctor test											
WEIGHT OF EMPTY MOULD = 4595gm											
SL. No	Water % added	Wt. f mould +soil gms	Wt. of soil gms	Wt density gm./cc	MOISTURE DETERMINATION						
					Container No.	Wt. of Container gms	Wt. of container + wet soil in gms	Wt. of container + dry soil gms	Wt. of water gms.	Moisture content %	Dry density kN/m ³
1	6	6340	1745	1.745	5	15.39	50	48.9	1.1	3.28	15.40
2	8	6416	1821	1.821	6	15.53	50	48.3	1.7	5.19	16.00
3	10	6513	1918	1.918	7	16.33	50	47.85	2.15	6.82	17.10
4	12	6557	1962	1.962	8	15.84	50	46	4	13.26	18.06
5	14	6558	1963	1.963	9	16.04	50	45.33	4.67	14.2	17.30
6	16	6551	1956	1.956	10	15.79	50	44.62	5.38	18.7	16.484

Optimum Moisture Content (OMC) 13.2%

Maximum Dry Density (MDD) 18.06 kN/m³

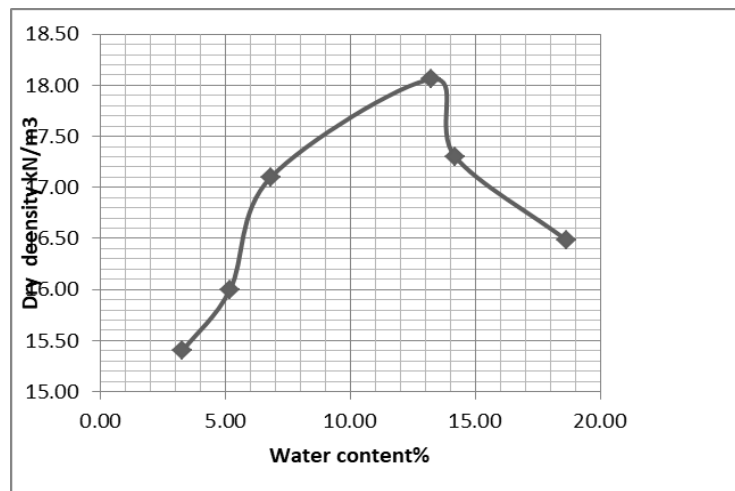


Fig 4.5 Water content and Dry Density relationship of 3m³ soils

4.7.5 Addition of 200ml Terrazyme at 2 m³ soil.

Modified Proctor test											
WEIGHT OF EMPTY MOULD = 4595gm											
SL. No	Water % added	Wt. f mould +soil gms	Wt. of soil gms	Wt density gm/cc	MOISTURE DETERMINATION						
					Container No.	Wt. of Container gms	Wt. of container + wet soil in gms	Wt. of container + dry soil gms	Wt. of water gms.	Moisture content %	Dry density gm/cc
1	6	6340	1745	1.745	5	15.39	50	48.95	1.05	3.13	16.90
2	8	6416	1821	1.821	6	15.53	50	48.36	1.64	5.00	17.34
3	10	6513	1918	1.918	7	16.33	50	47.83	2.17	6.89	17.53
4	12	6557	1962	1.962	8	15.84	50	46.2	3.8	12.52	17.99
5	14	6558	1963	1.963	9	16.04	50	45.45	4.55	15.47	17.32

Optimum Moisture Content (OMC) 13.5%

Maximum Dry Density (MDD) 17.9kN/m³

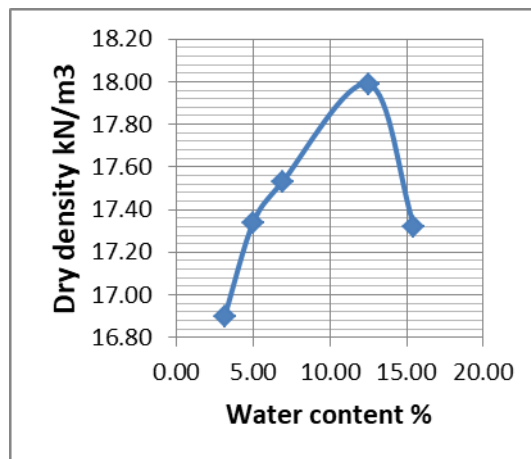


Fig 4.6 Water content and Dry Density relationship of 2 m³ soils

DIFFERENT TERRAZYME DOSAGES BEHAVIOUR	
DIFFERENT DOSAGE OF TERRAZYME AT DIFFERENT VOLUME (m ³)	DRY DENSITY kN/m ³
2	17.9
2.5	18.06
3	17.87
3.5	17.11
4	17.01

Table 4.7.6 Different terrazyme behaviour

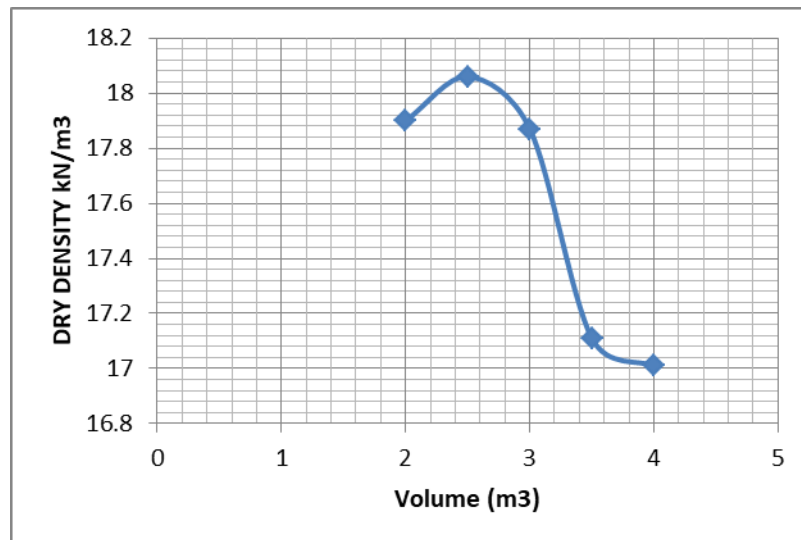


Fig 4.7 Different Terrazyme behaviour

4.8 UNCONFINED COMPRESSION TEST

4.8.1 UCS test for original soil sample

The unified compression test of original soil sample are tested below the table

Table 4.8.1 UCS test for original soil sample

USC TEST VALUE						
Disp. Dial gauge	Shear Disp (cm)	Corrected area	Proving ring	Shear (kg)	Shear stress (kg/sq cm)	Axial strain (%)
0	0	11.3411	0	0	0	0
50	0.05	11.4163	1.3	1.3	0.1139	0.658
100	0.1	11.4924	2.2	2.2	0.1914	1.316
150	0.15	11.5695	3	3	0.2593	1.974
200	0.2	11.6477	5.3	5.3	0.455	2.632
250	0.25	11.7269	6.8	6.8	0.5799	3.289
300	0.3	11.8072	8.4	8.4	0.7114	3.947
350	0.35	11.8887	10.2	10.302	0.8665	4.605
400	0.4	11.9712	11.8	11.918	0.9956	5.263
450	0.45	12.0549	12.6	12.726	1.0557	5.921
500	0.5	12.1398	13.4	13.534	1.1148	6.579
550	0.55	12.2259	14	14.14	1.1566	7.237
600	0.6	12.3132	13	13.13	1.0663	7.895

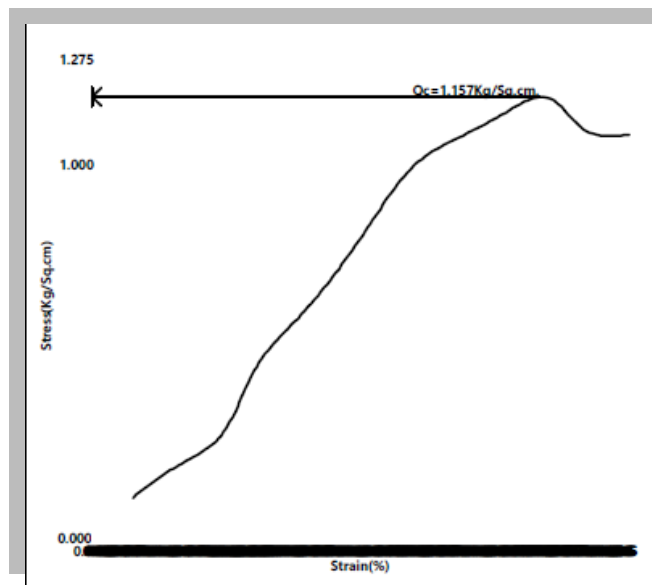


Fig 4.8(a) Stress strain relationship of original soil sample

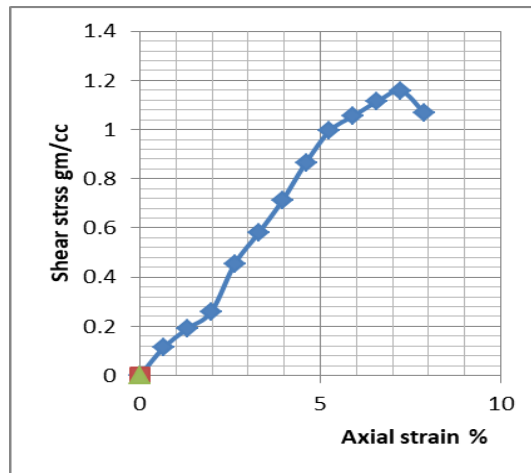


Fig 4.8(b) Stress strain relationship of original soil sample

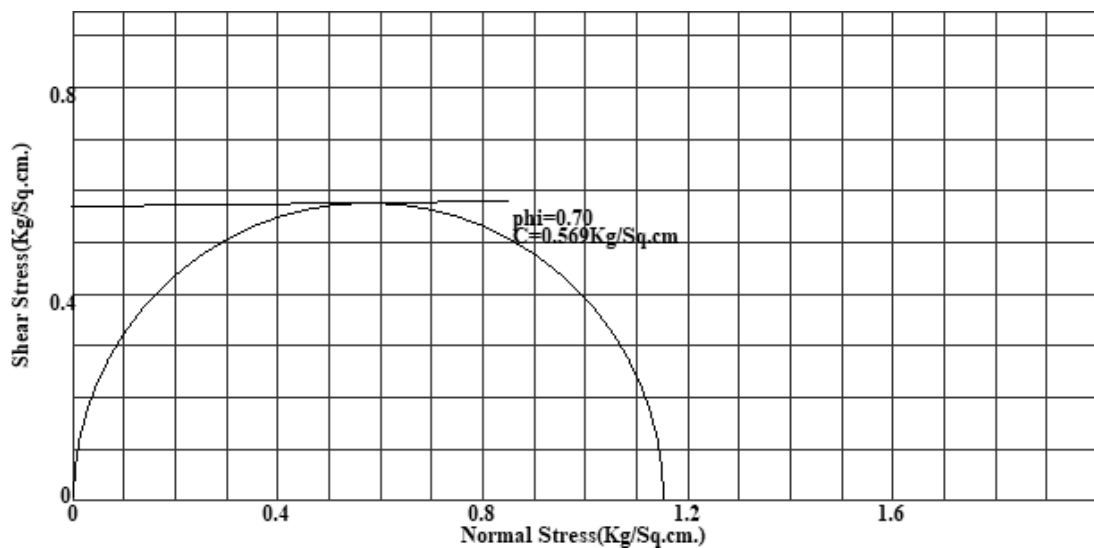


Fig 4.9 Mohr's circle

Original soil sample $\phi=0.70$ $C=.569$ Kg/sq. cm

Maximum stress = 1.157 Kg/sq. cm

TESTING OF TERRAZYME MIXED UCS TEST

As the study of different Literature Review, The different dosages of Terrazyme are taken for UCS test.

Different dosages (m3)	Quantity (ml)
4,3.5,3,2.5,2,1.5,1	200

Table 4.8.2 UCS test for addition of 200ml Terrazyme at 4 m3 soil.

Disp. Dial gauge	shear Displacement cm	corrected area	proving ring	shear (kg)	shear stress (kg/sq. cm)	Axial strain (%)
0	0	11.34	0	0	0	0
50	0.05	11.41	1.6	1.60	0.1402	0.658
100	0.10	11.49	2.4	2.40	0.2088	1.316
150	0.15	11.56	3.4	3.40	0.2939	1.974
200	0.20	11.64	5.8	5.80	0.4980	2.632
250	0.25	11.72	7.0	7.00	0.5969	3.289
300	0.30	11.80	8.6	8.60	0.7284	3.947
350	0.35	11.88	9.0	9.00	0.7570	4.605
400	0.40	11.97	11.0	11.11	0.9281	5.263
450	0.45	12.05	12.0	12.12	1.0054	5.921
500	0.50	12.13	13.0	13.13	1.0816	6.579
550	0.55	12.22	13.6	13.73	1.1235	7.237
600	0.60	12.31	14.2	14.34	1.1648	7.895
650	0.65	12.40	15.0	15.15	1.2216	8.553
700	0.70	12.49	15.0	15.15	1.2128	9.211
800	0.80	12.67	13.0	13.13	1.0359	10.526

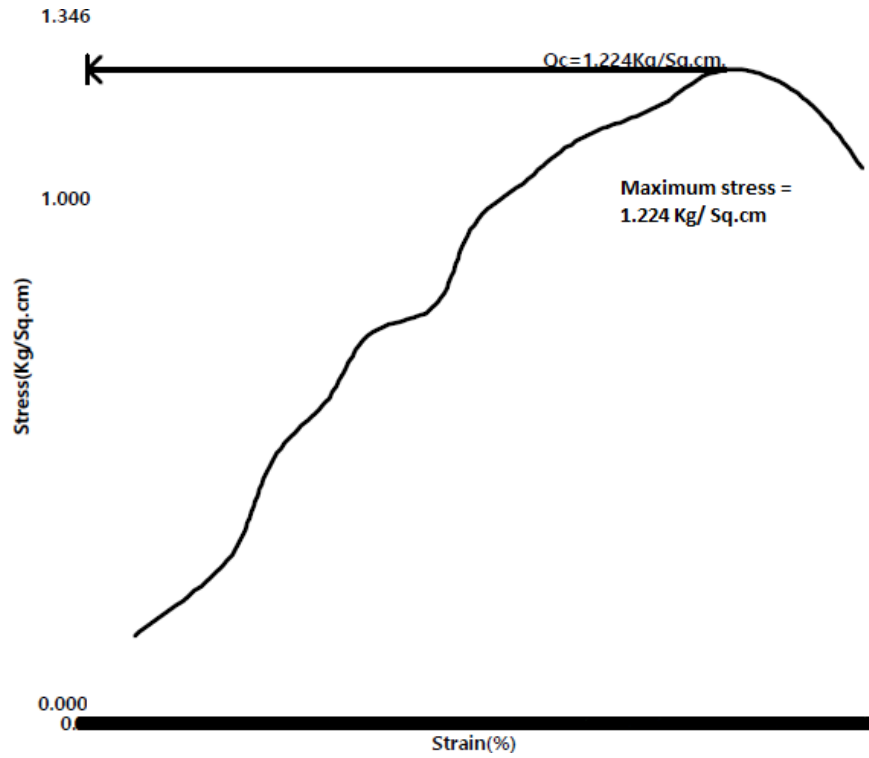


Fig 4.10 Stress strain relationship of 4m³ soil

Table 4.8.3 UCS test for addition of 200ml Terrazyme at 3.5 m³ soil.

Disp. Dial gauge	shear Disp cm	corrected area	proving ring	shear (kg)	shear stress (kg/sq. cm)	Axial strain (%)
600	0.60	12.3132	14.2	14.342	1.1648	7.895
650	0.65	12.4018	15.0	15.15	1.2216	8.553
700	0.70	12.4917	15.0	15.15	1.2128	9.211
800	0.80	12.6754	13.0	13.13	1.0359	10.526
200	0.20	11.6477	6.0	6.00	0.5151	2.632
250	0.25	11.7269	8.0	8.00	0.6822	3.289
300	0.30	11.8072	9.0	9.00	0.7622	3.947
350	0.35	11.8887	10.0	10.00	0.8411	4.605
400	0.40	11.9712	12.0	12.12	1.0124	5.263

450	0.45	12.0549	13.0	13.13	1.0892	5.921
500	0.50	12.1398	14.0	14.14	1.1648	6.579
550	0.55	12.2259	15.0	15.15	1.2392	7.237
600	0.60	12.3132	16.0	16.16	1.3124	7.895
650	0.65	12.4018	16.2	16.36	1.3193	8.553
700	0.70	12.4917	16.0	16.16	1.2937	9.211
800	0.80	12.6754	15.0	15.15	1.1952	10.526

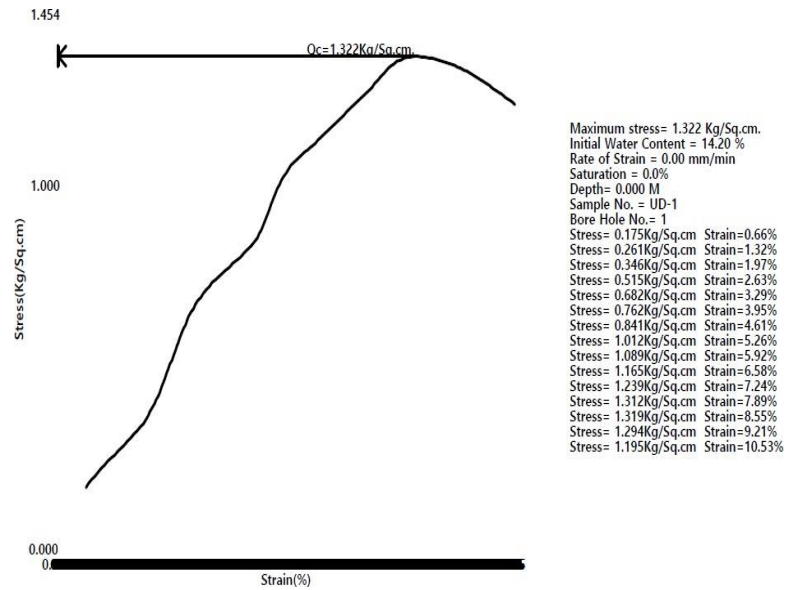


Fig 4.11 Stress strain relationship of 3.5 m³ soil

Maximum stress = 1.322 Kg/sq. cm

Table 4.8.4 UCS test for addition of 200ml Terrazyme at 3 m³ soil.

Disp. Dial gauge	shear Disp cm	corrected area	proving ring	shear (kg)	shear stress (kg/sq. cm)	Axial strain (%)
0	0	11.34	0	0	0	0
100	0.10	11.49	2	2.00	0.17	1.31
200	0.20	11.64	3	3.00	0.25	2.63
300	0.30	11.80	6	6.00	0.50	3.94
450	0.45	12.05	8	8.00	0.66	5.92
500	0.50	12.13	9	9.00	0.74	6.57
600	0.60	12.31	10	10.00	0.81	7.89
700	0.70	12.49	11	11.11	0.88	9.21
800	0.80	12.67	13	13.13	1.03	10.52
900	0.90	12.86	17	17.17	1.33	11.84
1000	1.00	13.05	18	18.18	1.39	13.15
1100	1.10	13.26	19	19.19	1.44	14.47
1200	1.20	13.46	17	17.17	1.27	15.78

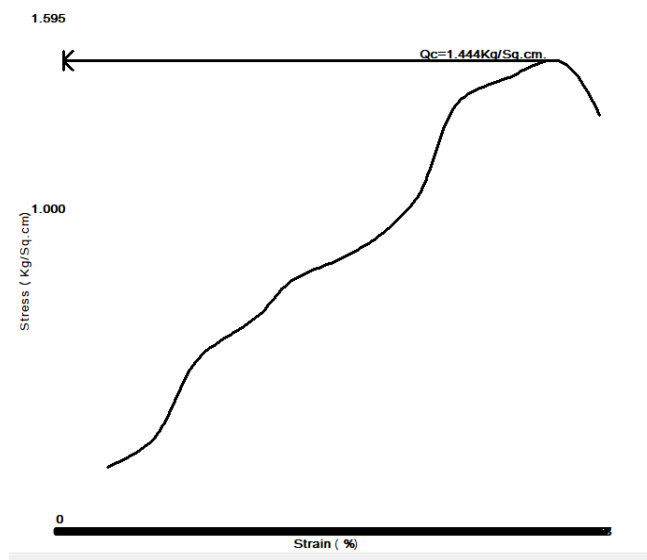


Fig 4.12 Stress strain relationship of 3 m³ soil

Maximum stress = 1.44 Kg/sq. cm

4.8.5 UCS test for addition of 200ml Terrazyme at 2.5 m³ soil.

Disp. Dial gauge	shear Disp cm	corrected area	proving ring	shear (kg)	shear stress (kg/sq cm)	Axial strain (%)
0	0	11.3411	0	0	0	0
50	0.05	11.4163	3	3.00	0.26	0.658
100	0.10	11.4924	5	5.00	0.43	1.316
150	0.15	11.5695	6	6.00	0.51	1.974
200	0.20	11.6477	7.2	7.20	0.61	2.632
250	0.25	11.7269	8.2	8.20	0.69	3.289
300	0.30	11.8072	9.8	9.80	0.83	3.947
350	0.35	11.8887	11.0	11.11	0.93	4.605
400	0.40	11.9712	13.0	13.13	1.09	5.263
450	0.45	12.0549	14.0	14.14	1.17	5.921
500	0.50	12.1398	16.2	16.36	1.34	6.579
550	0.55	12.2259	18.0	18.18	1.48	7.237
600	0.60	12.3132	19.4	19.59	1.59	7.895
700	0.70	12.4917	20.4	20.80	1.66	9.211
800	0.80	12.6754	19.0	19.19	1.51	10.526

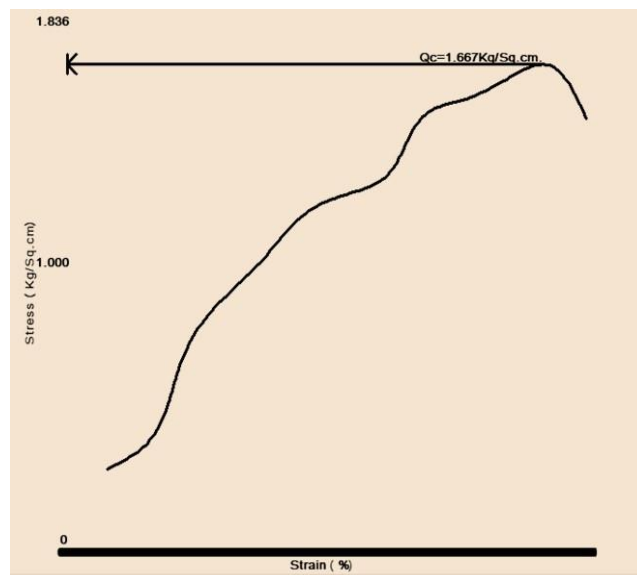


Fig 4.13 Stress strain relationship of 2.5 m³ soil

Maximum stress = 1.667 Kg/sq. cm

Table 4.8.6 UCS test for addition of 200ml Terrazyme at 2 m³ soil.

Disp. Dial gauge	shear Disp cm	corrected area	proving ring	shear (kg)	shear stress (kg/sq cm)	Axial strain (%)
0	0	11.3411	0	0	0	0
100	0.1	11.4924	3	3	0.261	1.316
200	0.2	11.6477	4	4	0.3434	2.632
300	0.3	11.8072	6	6	0.5082	3.947
400	0.4	11.9712	7	7	0.5847	5.263
500	0.5	12.1398	8	8	0.659	6.579
600	0.6	12.3132	9	9	0.7309	7.895
700	0.7	12.4917	11	11.11	0.8894	9.211
800	0.8	12.6754	13	13.13	1.0359	10.526
900	0.9	12.8646	15	15.15	1.1777	11.842
1000	1	13.0595	16	16.16	1.2374	13.158
1100	1.1	13.2604	18	18.18	1.371	14.474
1200	1.2	13.4676	19	19.19	1.4249	15.789
1300	1.3	13.6814	17	17.17	1.255	17.105

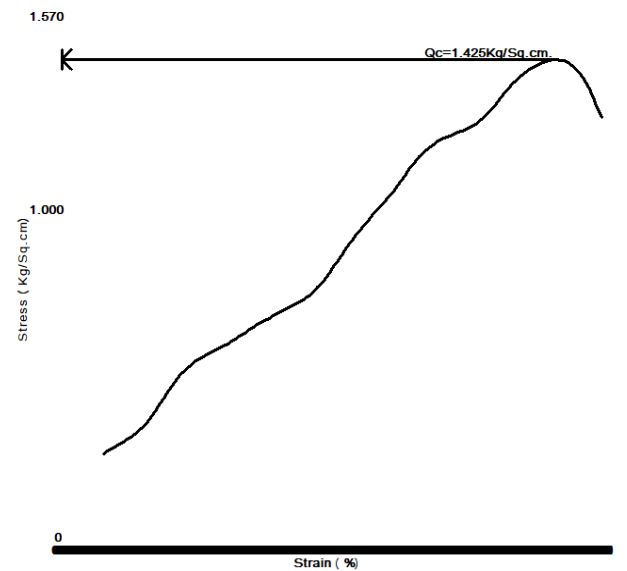


Fig 4.14 Stress strain relationship of 2 m³ soil

Maximum stress = 1.5 Kg/sq. cm

Table 4.7 UCS results under the different Terrazyme application dosages

DIFFERENT TERRAZYME DOSAGES BEHAVIOUR	
DIFFERENT DOSAGE OF TERRAZYME APPLIED IN DIFFERENT VOLUME (m ³)	UCS Kg/cm ²
2	1.500
2.5	1.667
3	1.440
3.5	1.322
4	1.224

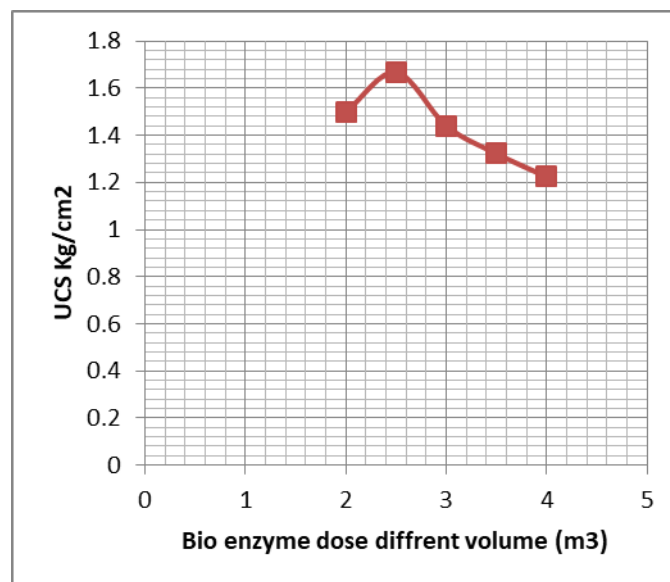


Fig 4.15 UCS results under the different Terrazyme application dosages

soil was mixed with Terrazyme with different dosages i.e. 3.5m³ per 200 ml, 3m³ per 200 ml, 2.5m³ per 200ml. Various test were performed and the results are as shown above all the graph.

Angle of shearing= 0.9 kg/cm²
Cohesion (C) =0 .90kg/cm²

In this Triaxial test, after adding the geocell block at L/2 distance of soil sample and Terrazyme the Cohesion value and phi value increased.

CHAPTER -5

5. CONCLUSION AND FUTURE SCOPE

5.1 CONCLUSION

In this present study an effort has been taken to enlighten the use of Geocell as a reinforcing material and Terrazyme as a soil stabilizer comparing their physical properties with original clay soil. Based on the experimental observation in current study following conclusions can be made.

- I. The induced apparent excessive strength depends on the position of the geocells from the top of the sample. It is observed that when the geocells are placed at half of the diameter /width of the loading area, maximum benefit in strength is achieved.
- II. Geocell reinforced soil does not show any failure stress under unconfined condition.
- III. Terrazyme as soil stabilizers can be used to improve the strength of subgrade due to low cost and relatively compared the standard stabilizer. Value.
- IV. Terra-zyme increase the strength of soil as well as its shearing parameters like ϕ , cohesion etc.

5.2 SCOPE FOR FUTURE STUDY

- I. Another type of bio enzyme like Perazyme, Fujibrton etc. can be used for their effect on the soil with varying stabilizing duration.
- II. Further test can be performed different composition of bio enzyme with triaxial compression test of soil improve the soil property with varying dosages as well as varying stabilization duration.
- III. Further test can be performed for permeability, direct shear test and dynamic behaviour of soil to improve the soil property.
- IV. The effect of Terrazyme on the consolidation properties of the soil can be studied.
- V. Bio-enzymes along with another additive like lime, Murom and other material can be used together and may be vary in quantity to obtain best possible result.

CHAPTER -6

6. REFERENCES

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