

# Compaction And Strength Characteristics of Terra Zyme And Hypo Sludge Stabilised Lithomargic Soil (Shedi Soil)

Subhadra GD<sup>1</sup>, Nandini DN<sup>2</sup>

<sup>1</sup>M tech Student, School of Civil Engineering, REVA University, Bengaluru, Karnataka, India

<sup>2</sup>Asst.Prof,School of Civil Engineering, REVA University, Bengaluru, Karnataka, India

\*\*\*

**Abstract** - Today engineers are responsible for specifying or selecting the correct technique, quantity of material required and stabilizing method. Stabilisation of soil with Bio enzymes and waste materials is a newly method to improve the geotechnical properties of the soil. In this present study, the effectiveness of Bio enzymes and waste materials like Hypo Sludge in stabilizing the soil of South Canara districts are investigated through laboratory experiments. The Lithomargic soil (Shedi soil) is collected from the field is used for the investigation. Bio enzyme (Terra Zyme) and Hypo Sludge are used as a soil stabilizer. The pavements of Udupi and Dakshina Kannada districts are found to be damaged due to improper drainage system and heavy rainfall added problems and another major failure of sub base due to improper material usage. The soils available in this region are Lateritic soil and Lithomargic soil. The plasticity index of the soil is found to be more due to high presence of silt and clay content in this type of soil. In this study, the Lithomargic soil sample are collected to investigate the geo technical properties and treated with variable dosage of Bio enzyme and variable percentage of Hypo Sludge. The strength parameters of the stabilized soil have been evaluated for a curing period of 0, 7, 14, 21 and 28 days.

**Key Words:-** Lithomargic soil, Terra Zyme, Hypo Sludge, Standard Proctor Test, UCS Test, CBR Test

## 1.INTRODUCTION

Engineers often faces problems with constructing facilities on or with soils, which do not have adequate potency to sustain the obligatory loads upon them either during construction or during the service time of structure. In India, many areas consist of earth with more silt contents with low strength and minimum bearing capacity. Therefore, for better performance of structures which are built on such soils, the characteristics performance need to be improved .The method of choice, depends mainly on soil type and properties to be enhanced, type and degree of enhancement required in a particular purpose. Recently, Bio enzyme and the Hypo Sludge has been found as a new substance for soil

stabilization .In the present study the Bio enzyme and the Hypo Sludge are used in various dosages and engineering characteristics of Shedi soil is evaluated.

## 1.1 Objectives of the study

Objectives of the current work are as follows:

- To assess the engineering characteristic of the Terra Zyme and the Hypo Sludge stabilized soil.
- To determine the result of the Hypo Sludge in soil stabilization, to reduce the waste disposal problem and environmental pollution.
- To arrive at a optimum Bio enzyme an Hypo Sludge content.

## 2. METHODOLOGY

**Materials used for the study:**

### 2.1 Lithomargic soil (Shedi soil):

Lithomargic soil is obtainable at depth of diminutive meters from the ground plane .Above this deprived layer of Shedi soil ,Laterite soil which possess reasonably high strength is present .For engineering activities The Shedi soil is found to be very problematic . Lithomargic soil strength is more during dry condition where the strength reduces significantly during increased moisture content .This type of soil is very common in all region of Dakshina Kannada districts .Now days ,industrialization is common due to which industries ,roads ,railway lines and other structures are emerging .The profile of the ground is highly undulating in Dakshina Kannada districts due to which roads or railways in cutting are common in this region .Therefore ,Lithomargic soil is responsible for the stability of slopes because Laterite soil withstands the relatively steeper slopes ,as filling material used is Lithomargic soil poses some problems .

**Table 2.1 Geotechnical characteristics of Shedi soil**

Gain size distribution (%) (IS-2720-PART-4-1985)	
Gravel size fraction	37.85
Sand size fraction	59.7
Silt and clay	2.45
Specific gravity (IS-2720-PART-3-1980)	2.4
Consistency limits (%)	
Liquid limit (IS-2720-PART-5-1985)	55
Plastic limit (IS-2720-PART-5-1985)	20
Plasticity index	35
Compaction test (Std Proctor Test) (IS-2720-PART-7-1980)	
OMC (%)	20.5
MDD kN/m <sup>3</sup>	1.66
Shear test (UCS test) kN/m <sup>2</sup> (IS-2720-PART-10-1991)	116.28
CBR test (%) (IS-2720-PART-16-1985)	
1) Un soaked	3.53
2) Soaked	2.89

**2.2 Bio enzyme (Terra Zyme)**

Its a formulated liquid enzyme and is extracted from vegetables and then fermented, which is natural, non toxic ,non flammable ,non corrosive that enhances the engineering characteristics, increases the soil compaction densities and increased soil stability .Enzymes facilitates catalytic reaction between clayey particle and organic cat ions and speeds up the cat ionic switch process and thus reducing thickness of layer..Bio enzymes can be treated with soil like sandy clay ,silty clay ,sandy silt ,plastic and non plastic clay ,sandy loam and loam mixed with clay .The Bio enzyme dosage level varies from one to five liters for five m<sup>3</sup> of soil and varies on soil type ,soil characteristics and product concentration .The cost of Terra Zyme is low ,simple application ,less expensive and transport is cheaper .

**Table 2.2: Properties of Terra Zyme**

1) Hazardous components	None
2) pH Value	Below 3.5 and above 9.5
3) Boiling point	2120F
4) Specific gravity	1.05
5) Melting point	Liquid
6) Evaporation rate	Same as water
7) Solubility in water	Complete
8) Appearance/Odour	Brown liquid/non-obnoxious

**2.3 Hypo Sludge:**

Hypo Sludge is a un used substance obtained from paper mill industries .Throughout the year Hypo Sludge is generated continuously and it behaves like a clayey material .Hypo Sludge consists of short fiber , ink and some other impurities .The presence of hydrated lime that is calcium hydroxide along with chemical impurities is referred as lime sludge .After de inking and re pulping process, Hypo Sludge is found to have higher moisture content .Hence it is dried

up before its usage in laboratory studies. Since the Hypo Sludge is waste substance it causes environmental pollution as the routes of disposal is by land spreading and land filling

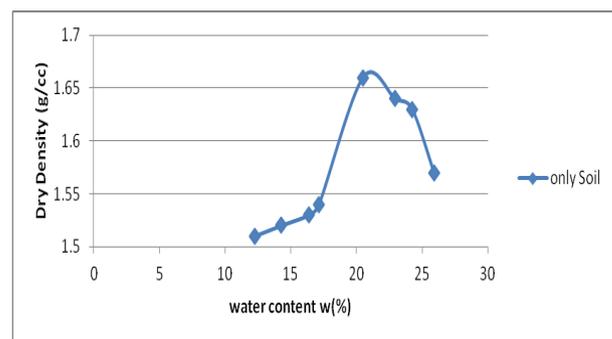
**Table 2.3 Chemical composition of Hypo sludge**

Chemical composition (IS 1760-1991)	
Silicon Dioxide (SiO <sub>2</sub> )	5.88%
Calcium Oxide (CaO)	47.51%
Magnesium Oxide (MgO)	2.99%
Sulphur Trioxide	<0.05%
Aluminium Oxide (Al <sub>2</sub> O <sub>3</sub> )	0.53%
Ferric Oxide (Fe <sub>2</sub> O <sub>3</sub> )	0.67%
Loss on Ignition	42.05%
Specific gravity	2.8

**3. Experimental results**

**3.1 Dosage of Enzyme and the Percentage of Hypo Sludge**

To decide the amount of Bio enzyme research studies are considered and it depends on the soil and it is taken as per/m<sup>3</sup>. Some of the researchers were considered the dosage based on the dosage recommended by the suppliers .Two researchers from CRRI (Central Road Research of India) namely Dr.Sunil Bose and Dr.P.K.Sikdar ,Delhi chooses the optimal dosage of Bio enzyme obtain by performing the CBR test value which also depending upon per/m<sup>3</sup> .In this experimental works three dosages namely 200ml/3m<sup>3</sup> D1 ,200ml/2.5m<sup>3</sup> D2, 200ml/2m<sup>3</sup> D3 of Bioenzyme is considered to study the geotechnical parameters of Shedi soil.



**Fig 3.1 Compaction curve for Virgin soil**

Fig 3.1 shows compaction curve for soil with no additive. From this curve OMC obtained is 20.5% and MDD obtained is 1.66 g/cc. To find the consequence of dosage level of Terra Zyme the above OMC and MDD are used.

Dry density = mass/volume

Bulk density of soil = 2.04g/cc

**Terra Zyme dosage calculation:**

Dry density obtained=1.66g/cc and Bulk density of soil=2.04g/cc.

For dosage D1:

200ml for 3m<sup>3</sup> of soil=3\*2.04\*1000=6120kg of soil.

for 1kg of soil=0.03 ml of enzyme.

For dosage D2:

200ml for 2.5m<sup>3</sup> of soil=2.5\*2.04\*1000=5100kg of soil.

for 1kg of soil=0.04ml of enzyme.

For dosage D3:

200ml for 2m<sup>3</sup> of soil=2\*2.04\*1000=4080kg of soil.

for 1kg of soil=0.05ml of enzyme

To decide the percent of usage of Hypo Sludge research studies are considered .In the experimental investigation ,to evaluate the geotechnical characteristics of Lithomargic soil 2% ,4% ,6% and 8% of Hypo Sludge is considered

**3.2 Testing Programme for Basic characteristics**

Tests are conducted to evaluate the Engineering parameters and geotechnical properties with virgin soil and stabilized soil .The details are tabulated in the table 2.1

**Table 3.2.1 Testing programme for basic characteristics of soil .**

Soil	Material type	Mix Proportions	Curing Period( days)	Test Conducted
Lithomargic soil	1)Terra Zyme	D1 ,D2 and D3	0 ,7 ,14 ,21 and 28 days	mpaction characteristics Unconfined Compression Strength California Bearing Ratio
	2)Hypo Sludge	2% ,4% ,6% and 8%		

**3.3 Compaction test**

The Light compaction test was conducted to conclude the Optimum moisture content and the maximum dry density and test procedure is according to (IS :2720 (PART-7)-1980),"Determination of moisture content –Dry density relationship using Light compaction").Standard Proctor Test equipment consists of ten cm diameter and twelve cm height mould and rammer of weight 2.6 kg. Soil is filled in 3 layers and each layer has given 25 blows from the rammer and height of free drop of rammer is 31 cm .Graph is plotted from the obtained values of the moisture content and the dry

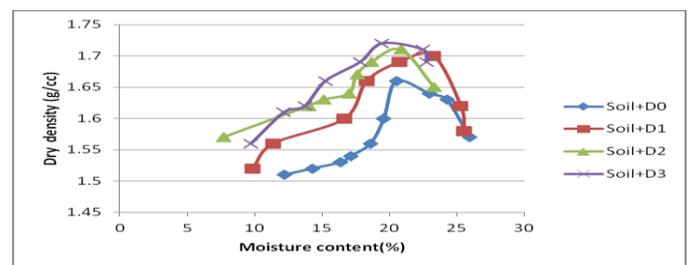
density .From crest of the graph the respective maximum dry density and optimum moisture content is determined

**Table 3.3.1:Light compaction test results for various dosage of Terra Zyme**

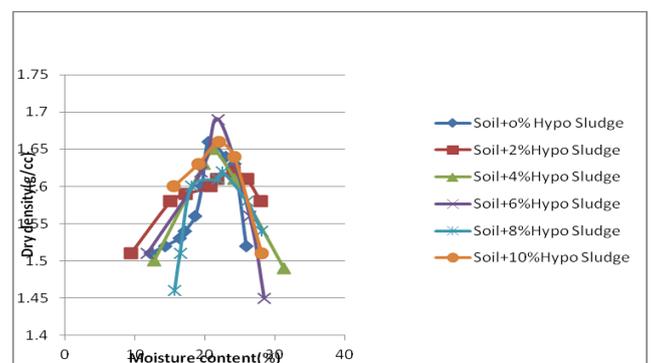
Dosage of Terra Zyme	Lithomargic soil	
	MDD(kN/m <sup>3</sup> )	OMC(%)
D0	16.28	20.5
D1	16.67	23.23
D2	16.77	20.87
D3	16.87	19.44

**Table3.3.2: Light compaction test results for various percentage of Hypo Sludge**

Percentage of Hypo Sludge	Lithomargic soil	
	MDD(kN/m <sup>3</sup> )	OMC(%)
0	16.28	20.5
2	15.89	24.09
4	16.18	21.19
6	16.57	21.91
8	15.89	22.54
10	16.28	21.96



**Fig 3.3.1: Compaction curve for various dosage of Terra Zyme**



**Fig3.3.2: Compaction curve for various percentage of Hypo Sludge**

### 3.4 Unconfined compression test

The Unconfined compression strength test was performed in lab to determine the Lithomargic soil's characteristic strength when treated with Bio enzyme and Hypo Sludge. The standard test methodology and

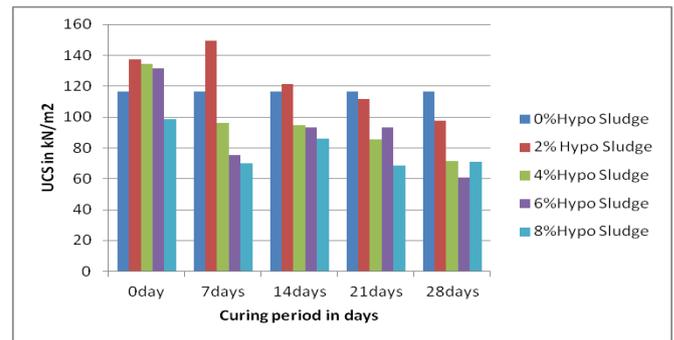
equipments are followed to perform the Unconfined compressive strength test in the present work .(IS:2720 (PART 10)-1973, "Determination of Unconfined compression strength test"). The Unconfined compression strength test was conducted with various dosages of Bio enzyme and various fraction of Hypo Sludge. The Bio enzyme dosage considered is D1 ,D2 and D3 and the Hypo Sludge percentage considered is 2% ,4% ,6% and 8% and for the both materials the curing period considered is 0, 7, 14, 21 and 28 days.

**Table 3.4.1:Unconfined compression strength test results for soil with different percentage of Hypo Sludge**

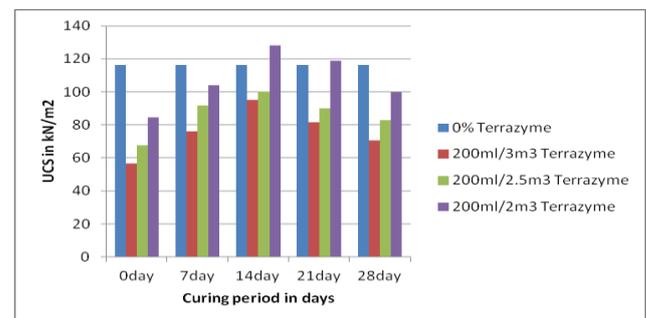
Curin g Perio d (days)	2% Hypo Sludge (MDD=15.89 kN/m <sup>3</sup> )(OMC=24.09%)	4% Hypo Sludge (MDD=16.18 kN/m <sup>3</sup> )(OMC=21.19%)	6% Hypo Sludge (MDD=16.57 kN/m <sup>3</sup> )(OMC=21.91%)	8% Hypo Sludge (MDD=15.89 kN/m <sup>3</sup> )(OMC=22.54%)
	UCC(kN/m <sup>2</sup> )			
0	137.34	134.3	131.60	98.51
7	149.63	95.97	75.40	70.25
14	121.24	94.56	93.07	86.04
21	111.53	66.75	92	68.75
28	97.52	56.65	60.98	71.04

**Table 3.4.2: Unconfined compression strength test results for soil with various dosage of Bio enzyme**

Curing period (days)	D1(MDD=16.67kN/m <sup>3</sup> )(OMC=23.23%)	D2(MDD=16.77kN/m <sup>3</sup> )(OMC=20.87%)	D3(MDD=16.87kN/m <sup>3</sup> )(OMC=19.4%)
	UCC(kN/m <sup>2</sup> )		
0	56.70	66.70	85.34
7	76.51	91.23	103.05
14	101.04	104.96	128.51
21	81.42	91.23	119.68
28	72.59	82.40	100.06



**Fig 3.4.1: Variation of UCS with curing period ,soil treated with Hypo Sludge**



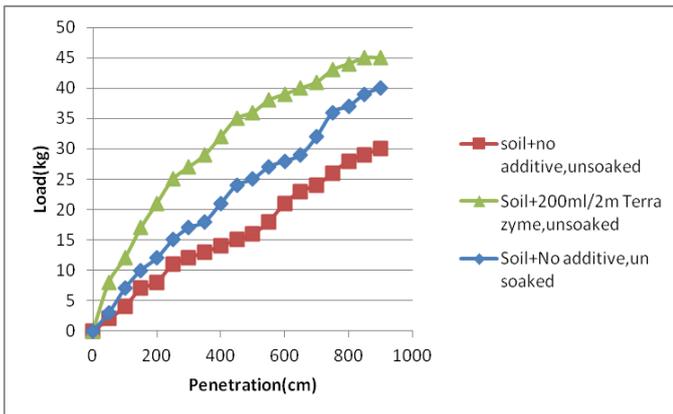
**Fig 3.4.2 : Variation of UCS with curing periods ,soil treated with Bio enzyme**

### 3.5 California bearing ratio test

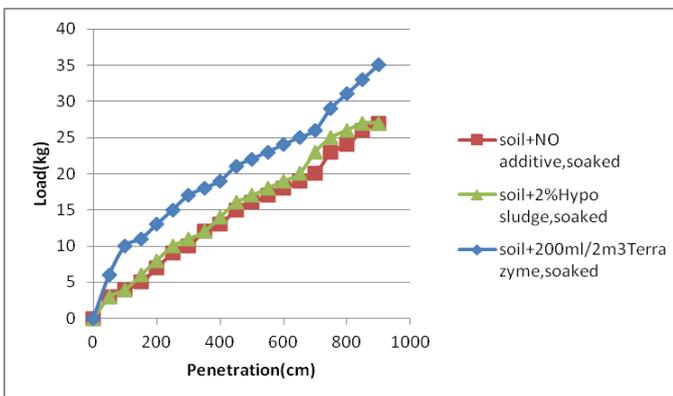
The available standard test procedure and equipment is used to conduct California bearing ratio test and in this work (IS-2720 (PART-16) 1979 , "Laboratory determination of California Bearing Ratio ") is followed .The CBR is conducted by considering the optimum content obtained from Unconfined compressive strength test .The test conducted for both soaked and un soaked condition .The optimum content obtained when soil mixed with dosage of Terra Zyme D3 and that for Hypo Sludge is 2% .The soaking period considered for both the material is 4 days .

**Table3.5.1: Un soaked and Soaked CBR test results**

	Bio enzyme=D3 (MDD=16.87kN/m <sup>3</sup> )(OMC=19.44%)	Hypo Sludge=2% (MDD=15.89kN/m <sup>3</sup> )(OMC=24.09%)
Un soaked CBR (%)	8.03	4.81
SoakedC BR (%)	4.81	3.21



**Fig3.5.1: Variation of load and penetration with optimum dosage of Terra Zyme and Hypo Sludge for Un soaked condition**



**Fig3.5.2: Variation of load and penetration with optimum dosage of Terra Zyme and Hypo Sludge for soaked condition**

#### 4. CONCLUSIONS

Based on the tests performed in the laboratory and obtained test results the following conclusions can be concluded.

- Bio enzyme (Terra Zyme) is a not toxic, non poisonous ,organic and biodegradable in nature and hence when it is pulverized with soil it undergo bio degradation in soil and its impact will remain permanent and hence it is environmentally not hazardous material.
- The initial cost of utilizing bio enzyme is high but it reduces the repair cost of road construction.
- The Lithomargic soil contains 37.85% of gravel, 59.7% of sand, 2.45% of silt and clay and this soil is classified as CL. The shedi soil specific gravity found to be 2.4.
- To use the Bio enzyme in road works, the soil should be cohesive in nature.
- Hypo Sludge which is industrial devastate material, on using these waste in road works reduces the disposal

problem of waste from industries and thus avoiding environmental pollution.

- The MDD and the OMC of Lithomargic soil after treating with optimal D3 amount of Terra Zyme is obtained to be 1.72g/cc and 19.44% and that treated with optimal 6% Hypo Sludge gives the values of 1.69g/cc and 21.91% respectively.
- From the test results obtained from the laboratory experiements ,when soil is added with Bio enzyme the compressive strength is found to raise by 116.28kN/m<sup>2</sup> to 128.54kN/m<sup>2</sup> that is increased by 10.54%. When soil treated with Hypo Sludge the compression strength is increased from 116.28kN/m<sup>2</sup> to 149.63kN/m<sup>2</sup> that is improved by 28.68% respectively.
- From the laboratory tests, when soil admixed with Bio enzyme, for un soaked condition the CBR is increased from 3.53% to 8.03% and for soaked condition the CBR increased from 2.89% to 4.81% .When soil mixed with Hypo Sludge ,for un soaked condition the CBR improved from 3.53% to 4.81% and for soaked state the CBR increased from 2.89% to 3.21%

#### 5.FUTURE SCOPE

- There are other Bio enzymes existing in other countries. So their outcome on stabilizing the soil can be is considered and also effect on different soils can be premeditated.
- With various dosage and different curing phase the result of Terra Zyme can be studied.
- Further tests like Permeability test, Consistency limits, Direct shear test, tests on dynamic behavior, Consolidation test of soil can be examined.
- Combination of the Terra Zyme and the Hypo Sludge on characteristics strength of soil can be studied and this can be tried on other variety of soil also.

#### 6. REFERENCES

- 1.Andrew, R.T., Fadi , M.S., Nicholos , E.H. and Elahe, M. (2003); "An Evaluation of Strength change on Subgrade soils stabilized with an Enzyme Catalyst solution using CBR and SSG comparisons", Geomatics, Inc. Columbia, Sc 29210,USA,JULY 2003.
- 2.Andromalos, K,B., Hegazy Y.A., Jasperse, B.H.(2000); "Stabilization of Soils by Soils Mixing" Proceedings, International Conference on soft ground technology, ASCE, Noorwijkerhout, Netherlands, pp. 194-205.

3. Brazetti, R. Murphy, S.R.(2000); "General usage of Bio-Enzyme stabilizers in Road Construction in Brazil", 32<sup>nd</sup> annual meeting on paving Brazil, October 2000.

4. "Effects of Terrazyme usage on increase of CBR", Technical report by Soil Mechanics Laboratory, National Road Department, Thailand, 1996.

5. Fine, L, Remington J,(1972); The corps of Engineers; Constructions in the United States. Airfields for Very Heavy Bombers.

6. Hitam, A. and Yusof, A. (1998); "Soil stabilizers for plantation of roads", National seminar on Mechanisation in Oil Palm Plantation, 30 June 1998, Selangor, Malaysia.

7. IRC: 37-2001 "Guidelines for the design of flexible pavements", The Indian Roads Congress, New Delhi.

8. ICR: SP: 20 -2002 "Rural roads Manual", The Indian Roads Congress, New Delhi.

9. IS 2720 (Part III) (1980) "Determination of Specific gravity" Bureau of Indian Standards, Manak Bhavan, New Delhi.

10. IS 2720 (Part IV) (1975) "Determination of Grain Size" Bureau of Indian Standards, Manak Bhavan, New Delhi.

11. IS 2720 (Part V) (1985) "Determination of Liquid and Plastic limit" Bureau of Indian Standards, Manak Bhavan, New Delhi.

12. IS 2720 (Part VII) (1980) "Determination of Moisture content and Dry density" Bureau of Indian standards, Manak Bhavan, New Delhi.

13. Roger, B. (2006); "Soil stabilizers on universal accessible trails", Technical Report 0023-1202-SDTDC, San Dimas, Ca: U.S. Department of Agriculture, Forest Service, San Dimas Technology and Development Center, 10 p.

14. Ryan, C.R. and Jasperse, B.H.(1989): "Deep Soil Mixing at the Jackson Lake Dam". ASCE Geotechnical and Construction Divisions. Special Conference, Evanston, IL.

15. Satoni, R.L., Tingle, J.S and Webster, S.L. (2001): "Nontraditional Stabilization of Silty Sand" .U.S .Army Research and Development Center