ISSN (Online): 2456-0448
International Journal Of Innovative Research In Management, Engineering And Technology
Vol. 3, Issue 1, January 2017

EFFECT OF BIOENZYME –TERRAZYME STABILIZATION ON COMPACTION AND UNCONFINED COMPRESSIVE STRENGTH OF KUTTANAD SOIL

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Abstract: The conventional methods used nowadays are very much time consuming and not economically feasible. There is an urgent need for developing new technique to enhance the geotechnical properties of the soil.

Bioenzyme is a natural and non- toxic material from vegetable extracts. Their efficiency will depend on the amount of dosage, type of soil and field conditions. As the enzyme is an organic liquid it doesn't have any impact on environment. The stabilization of soil with bio-enzyme is a revolutionary technique which is becoming popular. Some bio-enzyme stabilized roads have been constructed in various parts of India, which are performing well. This paper mainly focuses on kuttanad clay treated with terrazyme and shown significant improvement in strength characteristics.

Keywords : kuttanad soil,bioenzyme,soil stabilization

I. INTRODUCTION

When only poor-quality soil is available at the construction site, the best option is to modify the properties of the soil so that it meets the design requirements. The process of improving the strength and durability of soil is known as soil stabilization. It is the alteration of soils to enhance their physical properties. Stabilization can increase the shear strength and control the shrink-swell properties, thus improving the load bearing capacity of the soil. The main aims of stabilization are cost reduction and efficient use of locally available material. Most common application of stabilization of soil is seen in construction of roads and airfields pavement.

Kuttanad is situated in the central half of Kerala covering an area of approximately 1100 sq. km and lies 0.6 m to 2.2 m below the mean sea level. Kuttanad clay is an important soil group, well known for its low shear strength and high compressibility. Soil in this region is soft black or grey marine clay composed of minerals such as montmorillonite, kaolinite, iron oxide and aluminum oxide (shrisath et al.,2017). The natural water contents of this soil are very high and close to liquid limit, sometimes even exceeding it. The typical kuttanad soil consists primarily of silt and clay fraction. It is a weak foundation material, with a number of failures to structures and embankment reported. Since Kuttanad is the rice bowl of Kerala, any ground improvement technique adopted in this region should be eco-friendly and should never cause any harm to the environment, especially to the soil and water. Thus, the presently used methods of physical improvement such as preloading and chemical improvement by addition of adulterants might prove to be inefficient in the present scenario, wherein the focus is on fast sustainable technologies. All cement-based techniques may seem harmless to the public eye, but add to carbon footprint heavily during manufacture. The improvement of subsoil using alternative biological or ecofriendly chemical methods is thus a growing concern, and the focus of the present paper. In particular, the paper focuses on bioenzyme an alternative sustainable technique which can be potentially utilized to improve Kuttanad clay.

Bioenzymes are natural, non-toxic, non-flammable organic and liquid concentrated substances from vegetable extracts namely (Saini and Vaishnava,2015).Soil types stabilized by bioenzymes include sandy clay ,silty clay, sandy silt, plastic and non-plastic clay, sandy loam, fine loam, and loam mixed with clay. The dosage level of bioenzyme vary from 1 litres for 5$m^3$of soil depending on the soil type and soil characteristics. Bio enzyme

reduces the voids between the particles of soil and minimizes the amount of absorbed water in the soil so that compaction caused by enzymes can be maximum. These enzymes have been proven to be very effective and economical. The use of bioenzyme in soil stabilization is not very popular due to lack of awareness. Recently there are many bio-enzymes available for soil stabilization such as Renolith, Permazyme, Terrazyme, Fujibeton etc. Most commonly used one is terrazyme.

2.Terrazyme

Terrazyme modified from vegetable extracts is specially formulated to modify the engineering properties of soil,usually applied as a mixture with water.terrazyme acts on the soil by reducing the void space between the particles minimizing the adsorbed layer of water and maximizing compaction. It reacts with the organic materials to form cementatious material,bringing about a decrease in permeability and increase in chemical bond, creating a permanent structure resistant to weather,wear and tear (Gupta etal.,2017).Table1 shows the properties of terrazyme(Shirsath et al.,2017).

Table 1: Properties of Terrazyme (Shirsath et al.,2017). Property

Value/specification Boiling point 212°f	
Specific gravity	1 to1.09
Ph value	4.3 to 4.6
Hazardous content	None
Appearance	Brown colored liquid
Reactivity data	Stable

2.1 Mechanism of terrazyme

Soil (clay) has surface negative charges particles making the soil attracted to the positive charge and get neutralized. It is found that the adsorbed layer of water contains metals like Na,K,Al,Mg which is the reason for the bond between negative clay particles

and water molecules. Thus a significant layer of water is created around soil particles and to attain compaction it is necessary to eliminate the water layer around the particle .terrazyme reduces the dielectric charge in water molecule thus creating pressure on the positive metal ions to release the free water. This breaks the electrostatic potential barrier therby reducing the thickness of the diffused double layer so that the soil particles come closer and attain greater compaction with less compactive effort (Eujine et al.,2014).

2.2 Effect of terrazyme on clays

Effect of terrazyme is different for different types of soil and mainly dependson dosage and curing time. With the addition of terrazyme a significant increase in the values of both soaked and unsoaked CBR has been observed ,by as much as 4 times for clayey silts(Saini and Vaishnava,2015). This is because of increased compaction creating stronger bond which resist penetration. The OMC and consistency limitshave alsobeen found to decrease,indicating the denseness of the soil.permeability of the soil also has decreased with the increase in curing time compared to that of sample untreated with terrazyme. It is due to the decrease in voids after enzyme action thereby not allowing the water to flow through the soil (Gupta et al., 2016). Terrazyme decreased liquid limit by as much as 28% and shrinkage limit by 30% in two weeks on high liquid limit clays but had little effect on plastic limit (Eujine et al.,2014)effect of terrazyme for different types of soil varies and it mainlydepends on dosage. Studies have been reporting the variations on geotechnical properties for different dosage of terrazyme for (type of soil) (Saini and Vaishnava,2015)

3.Materials and Experiments

3.1 Soil properties

The soil used in the work is kuttanad clay collected from pallipadu in, Alappuzhadistrict. Samples were air dried for a week and broken down into smaller pieces. As per the results of initial test soil was classified as MH as per Unified Classification System. The initial properties of collected soil are given in table 1.

Table 1: Properties of kuttanad soil

SL.NO	PROPERTY	VALUE
1.	SPECIFIC GRAVITY	2.56
2.	PARTICLE SIZE DISTRIBUTION	
	CLAY (%)	46
	SILT (%)	46.8
	SAND (%)	7.2
3.	ATTERBERGS LIMIT	
	LIQUID LIMIT ,W_L	67
	PLASTIC LIMIT,W_P	54.68
	SHRINKAGE LIMIT,W_S	24
	SOIL CLASSIFICATION	MH
4	UNCONFINED COMPRESSIVE STRENGTH (kN/m^2)	15.3
	STANDARD PROCTOR COMPACTION TEST	
	MAXIMUM DRY DENSITY (g/cc)	1.2
	OPTIMUM MOISTURE CONTENT (%)	32

3.2 Specimen preparation

The soil was oven dried for 24 h. The bioenzyme used in this study is in liquid form and mixed with water and then poured on to the soil .bioenzyme concentrations of 0.5,1,1.5,2ml were used in the study.The soil is treated with optimum dosage of bioenzyme as obtained from the journal (Saini and Vaishnava,2015).

3.3 Test procedure

A modified Proctor Compaction test was performed for determining the maximum dry density and its corresponding optimum moisture content. Unconfined compressive strength tests were performed on soil- terrazyme specimens.

4.Results and Discussions

4.1 Effect of bioenzyme on compaction characteristics

Compaction is a primary process used in improving surface soil layers, where the soil is compacted to a certain density level after being mixed with a stabilizing material. The

achieved compaction will affect other mechanical characterizations such as shear strength, settlement, and bearing capacity.

The optimum moisture content (OMC) and maximum dry density(MDD) of soil without terrazyme are found to be 32% and 1.2g/cc with the addition of terrazyme the MDD increased to as much as 4 times and simultaneous decrease in OMC was observed from table 3.

Table 3 :Variation of OMC and dry density with terrazyme dosages

TERRAZYME DOSAGES (mL)	DRY DENSITY(g/cc)	OMC(%)
0.5	1.71	20
0.75	1.77	18
1	1.83	16
1.25	1.85	15
1.5	1.725	19.5

From the table it can be observed that the dry density increased with the increase in dosage of terrazyme upto
1.25 ml and then decreased at 1.5 ml hence it can be concluded that the optimum dosage is at 1.25ml terrazyme.

4.2 Effect of bioenzyme on UCS

UCS is the maximum axial compressive stress a right cylindrical sample of soil or any other material can withstand under unconfined (confining stress is zero) conditions. UCS test basically gives the strength of the soil so to determine the effect of terrazyme it is necessary to know the changes on UCS. The initial UCS value on kuttanad soil without the effect of terrazyme is 15.3kN/m^2.From the table shown below it is found that the UCS value increased with increase in dosage of terrazyme upto 1.25ml and decreased at 1.5ml thereby it can be concluded that 1.25 ml as optimum dosage

Table 4 : Variation of UCS with terrazyme dosages

TERRAZYME DOSAGE (ML)	**UCS (kN/m^2)**
0.5	20
0.75	32
1	46
1.25	70
1.5	68

5. Conclusions

Using experimental investigations, the following conclusions can be drawn:

1. Bioenzyme are environmental friendly alternatives to conventional soil stabilizing agents like cement, lime etc.
2. Dry density for the given soil increased from 1.2 g/cc to 1.8g/cc signifying the densification of soil the voids between the soil particles have decreased and the soil has achieved greater compaction at minimal compactive effort.
3. Significant increase in the UCS value from 15.3 kN/m^2 to70 kN/m^2.
4. Initial cost of bioenzyme is high but in the long-run it is economical.

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