STABILIZATION OF AN EXPANSIVE SOIL USING BIO-ENZYME

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Abstract: Expansive soils or Black Cotton soils are known for highly swelling & shrinking behaviour with moisture content variations. These soils belong to Clay group and are not reliable for construction or raising structures. These disadvantages can cause remarkable economic losses, as well as act a source of risk to the population. In this study an attempt has been made for improvement of geotechnical properties of selected expansive soil by addition of Bio-Enzymatic mixture (Terrazyme). The Bio-Enzyme is a liquid additive, when mixed with water and added to soil alters the engineering properties. The effectiveness of Bio-Enzyme depends upon the type of the soil and dosage of enzyme used for the intended purpose**.** The Bio-Enzyme acts on the soil and reduces the voids between soil particles and minimizes absorbed water in the soil thereby fetching for attainment of maximum compaction**.** In the present works, series of tests have been conducted on selected expansive soil with different dosages of Bio-Enzyme (Terrazyme) and varying curing periods**.** The laboratory test results have shown much improvement in its fatigue behavior and its strength in terms of California Bearing Ratio (CBR)**.**

Key Words: Expansive soil, Black Cotton Soil, Bio-Enzyme ,Plasticity Characteristics, California Bearing Ratio.

1. Introduction:

The “expansive soils” are those which experience high changes in volume with variation in their moisture content. These types of expansive soils are extensively circulated throughout the world (Huang and Wu, 2007, Sabtan, 2005).This type of soils contain Smectite group Clay mineral such as Montmorillonite orIillite (Chen et al., 1975; Sabtan, 2005; Nowamooz and Masrouri, 2008; Avsar et al., 2009). These soils are characterized by having a very small size particles, large specific surface area and high Cation Exchange Capacity (Fityus and Buzzi,2009; Nalbantogle, 2004; Nalbantogle and Gucbilmez, 2001).Volumetric changes of these types of soils cause high damage to the structures and infrastructure (Assadi and Shahaboddin, 2009; Avsar et al, 2009; Chen et al., 2007; Ferber et al.,2009; Huang and Wu, 2007).Stabilization of soil is a combination of physical and chemical methods for improving a properties of soil or engineering performance when it is used for or as a construction materials (Hans et al.1991). Stabilization can increase the strength of a soil and control the shrink-swell properties of a soil, thus improving the load bearing capacity of the existing soil or sub-grade to support pavement and foundations. Stabilization can be used to treat a wide range of sub-grade materials from expansive clay to granular materials.Thesoil stabilization is only one of several techniques available to the geotechnical engineer and its choice for any situation should be made only after comparison with other techniques which indicates it to be the best solution to the problem.In the recent times, a new soil stabilization technique categorized as “Green Technologies” have been introduced commercially in to the market. A few of these

technologies includeusage of enzymes (Guthrie et al., 2015), biopolymers (Chang et al., 2015), tree resins (Onyejekwe et al., 2015;Arasan et al., 2015), organic fiber reinforcement (Gobinath et al., 2015). While many of these products promise users better soil stabilization after treatment with curing time.Limited research work is available on various commercial products (Kestler et al., 2009). Commerciallyavailable bio-enzymes are Permazyme, Renolith, Fujibeton and Terrazyme(Rajoria and Kaur, 2014).The use of a terrazyme for soil stabilization while comparing with that of cement stabilization stated that Bio-Enzymes are more environment friendly and its use saved about 30% of the cost of construction on when compared tocement stabilization (Li et al., 2011).Studies on the effects of permazyme and quicklime on soils has indicated that the enzyme mixture was more effective compared with that of quicklime mixture (Peng et al., 2011).The Swelling Potential and Swelling Pressure from one dimensional consolidation load cell using swell and load procedure, Scanning Electron Microscope studies and Cation Exchange Capacity tests were reported by (Naagesh et al., 2010). The studies indicate thatBio-Enzyme use the mechanism of Cation Exchange Capacity to improve expansive soil properties.Bio-Enzymes are reported to increase the durability of sub-grade soils as well they biodegradable and environment friendly(Shankar et al.,2009; Shukla et al.,2003).

2. Materials used:

2.1. Soil:

Expansive soil sample collected at 3m depth from ground surface ofGajulamandam, Tirupati, Andhra Pradesh, India.

2.2. Bio-Enzyme (Terrazyme):

A bio-enzyme mixture namely Terrazyme procured from Avijeet Agencies in Chennai, India was used. Terrazyme is a natural, non-toxic liquid, formulated with enzyme extracts from vegetable and plant sources.Different dosagesof Terrazyme used in this work is presented in Table.1.Dosage was applied to the soil with reference to the weight of the soil.The treatment dosages of the Bio-Enzyme are expressed in terms of per m^3 of the soil-terrazymemixture. The thoroughly mixedsoil samples were sealed in polythene bag for 24h andthen tests wereconducted at different curing times.

Table.1: Dosages of Terrazyme used

Dosage	Amount of soil (kg)	Volume of Terrazyme(kg/ml)
D_1	3.5	0.029
D_2	3	0.034
D_3	2.5	0.041

2.3. Methods Adopted:

Liquid Limit test and Plastic Limit tests were conducted usingCasgrande's apparatus according to the standard procedures laid in IS: 2720 (Part 5)–1985.The soil-terrazyme mixture sample strengths were evaluated from unsoaked California Bearing Ratio (CBR) tests according to Indian Standard procedure(IS 2720: Part 16

3. Results and Discussion

Expansive clays impose various structural problems due to their sensitiveness to slight changes in the moisture content. These soils pose problems on account of their high compressibility and low strength also. In order to reduce these problems Bio-Enzyme (Terrazyme) is used nowa days to stabilize soft clays.The Plasticity Characteristics and Strength of the selected soil is analyzed from the respective test results obtained from a series of tests on soil-terrazyme mixtures varying amount of terrazyme and curing time. The tested soil properties are presented in table.2.

3.1. Plasticits Characteristics:

The Plasticity Characteristics of soil –Bio-Enzyme mixtures are studied with varying dosages of Bio-Enzyme and varying curing times (Soil-Terrazyme mixtures).The soil samples were mixed with three dosagesD_1,D_2 and D_3 of Terrazyme and cured for 0, 3,7 and 14 days. The variation of Plasticity Characteristics of selected soil alone and after treating with Terrazyme is presented in table.3..The Liquid Limit, Plastic Limit and Plasticity Index of untreated soil are 94.0%, 28.9% and 65% respectively. Fig.3. shows the variation of Liquid Limit, Plastic Limit and Plasticity Index with dosage of Enzyme and curing time. From the graphs 1, 2, and 3, it can be observed that Liquid Limit and Plastic Limit of the treated soil decreases with increasing dosages of the Bio-Enzyme due to reduction in the electric charge of the hydrogen ions in the absorbed water molecules, forming bond with the clay particles and thereby reducing thickness of the film ofadsorbed water that enveloped the clay particles.

Table.2: Properties of the tested Soil Sample

S. No	Properties	Values
1.	Specific Gravity	2.67
2.	Grain Size Distribution	
	Gravel (%)	1.5
	Sand (%)	56.3
	Silt + Clay (%)	42.2
3.	Plasticity Characteristics	
	Liquid Limit (%)	94.0
	Plastic Limit (%)	28.9
	Plasticity Index (%)	65.0
4	Free Swelling Index	210.0
5	I.S Soil Classification	SC (Clayey Sand)
6	Compaction Characteristics (I.S Heavy Compaction)	
	Optimum Moisture Content (%)	16.9
	Maximum Dry Density (kN/m^3)	17.30
7	CBR (%) (Unsoaked)	6.8

Table.3. Plasticity Characteristics of soil –Bio-Enzyme mixtures

Bio-Enzyme	Liquid Limit				Plastic Limit				Plasticity Index			
	0 day	3rd day	7th day	14th day	0day	3rd day	7th day	14th day	15th day	3rd day	7th day	14th day
D1(0.029kg/ml)	94.0	93.0	91.8	91.2	28.9	28.0	28.4	26.8	65.1	65.0	64.8	64.4
D2(0.034kg/ml)	93.0	92.0	91.6	90.6	28.0	27.6	29.0	29.0	65.0	64.4	62.6	61.6
D3(0.041kg/ml)	91.0	91.0	89.0	88.0	28.0	28.8	29.6	29.8	63.0	62.2	59.4	58.2

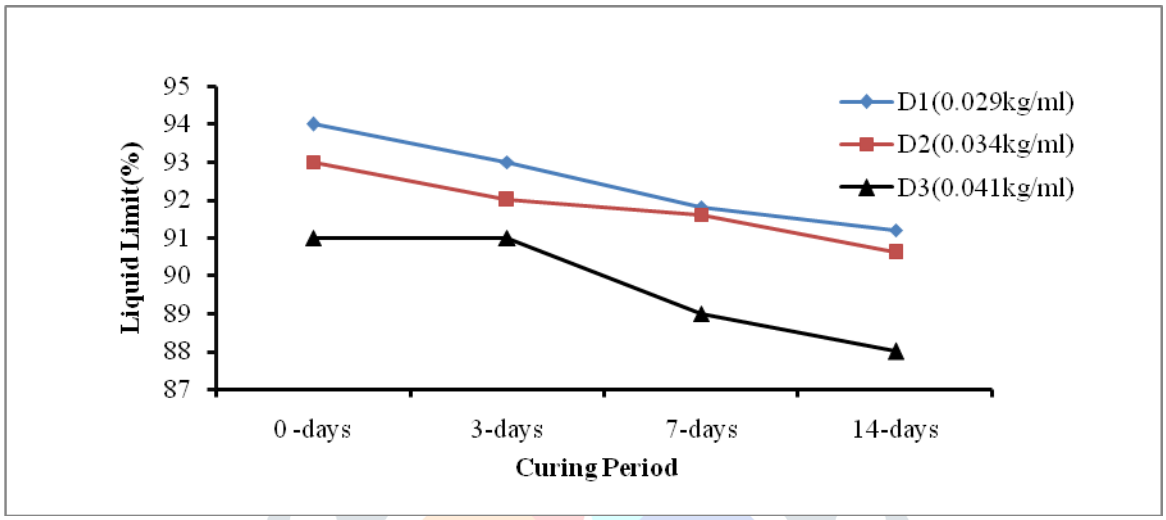

Figure – 1: Variation of Liquid Limit of the Treated Soil Samples with the Dosage of Bio-Enzyme and Curing Times.

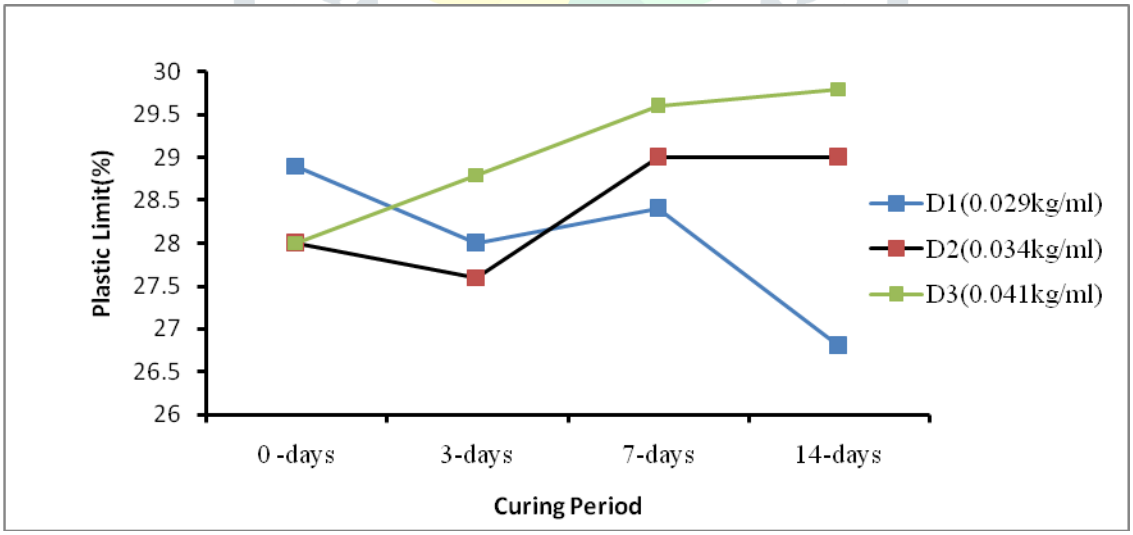

Figure – 2: Variation of Plastic Limit of the Treated Soil Samples with the Dosage of Bio-Enzyme and Curing Time.

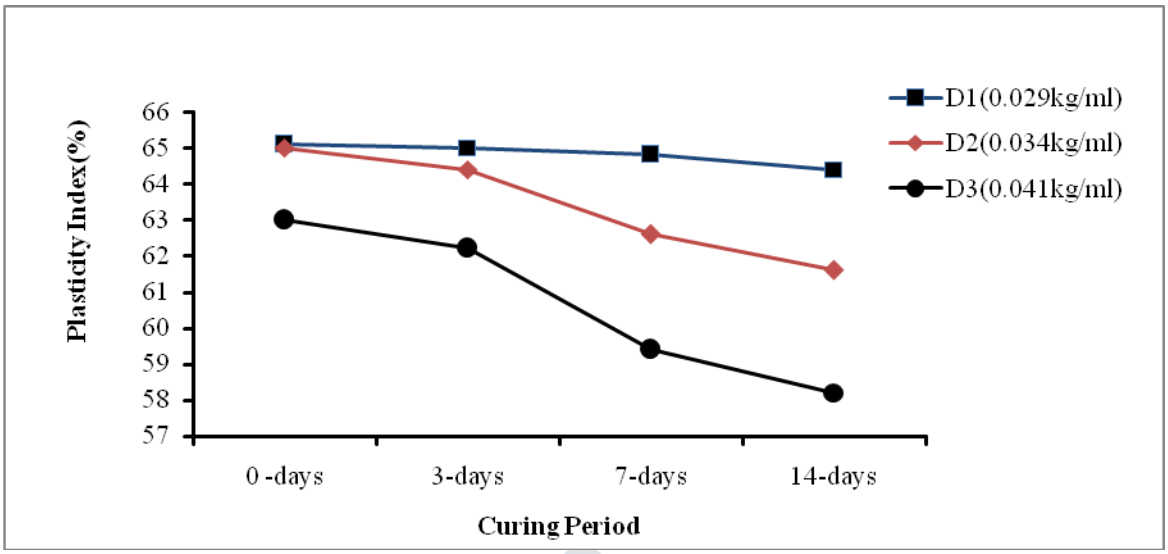

Figure – 3: Variation of Plasticity Index of the Treated Soil Samples with the Dosage of Bio-Enzyme and Curing Times.

3.2. Strength:

The soil –Bio-Enzyme (Terrazyme) samples were mixed with three dosages D_1, D2 and D_3 of terrazyme cured for different curing times. California Bearing Ratio(C.B.R) tests wereconducted in unsoaked conditions.TheCalifornia Bearing Ratio values are presented Table.4.The C.B.R values are found to increase by 84% for 14days curing andwith increasing dosages of Bio-Enzyme (D_3). The variation of unsoaked C.B.R values for soil-Bio-Enzyme mixtures (Terrazyme) with curing times are shown in Fig.4.

Table.4: CBR of soil –Bio-Enzyme mixtures

Dosage/ CBR (%)	Bio-enzyme Treatment			
	0-Days	3-Days	7-Days	14-Days
D1(0.029ml/kg)	7.3	8.4	9.1	9.39
D2(0.034ml/kg)	8.39	9.12	9.41	10.21
D3(0.041ml/kg)	9.34	10.29	11.38	12.4

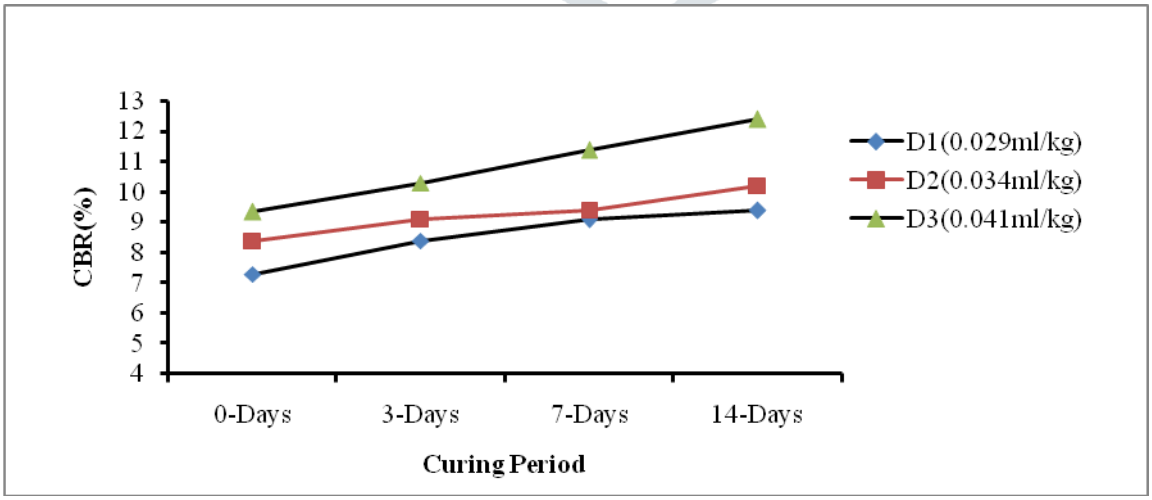

Figure -4: Variation of CBR of the Treated Soil Samples with the Dosage of Bio-Enzyme and Curing Times.

4. Conclusions

The Bio-Enzyme namely Terrazyme is used for stabilizing highly expansive soil obtained from Gajulamadam near Tirupati. Three dosages of Bio-Enzyme namely D_1,D_2 and D_3 are selected for stabilizing this expansive soil, since further increase in dosages are formed to be ineffective in improving strength of the soil. The following remarks are made from the present work:

1. The effect of Bio-Enzyme can be said to be nominal in improving the Plasticity Characteristics.
2. The strength of the soil expressed in terms CBR value is increasingwith increase in the dosage of Bio-Enzyme (Terrazyme) and with curing time.
3. The unsoaked CBR value increased by 84% with D_3dosage and waiting for 14-days curing.
4. The use of Bio-Enzyme (Terrazyme) in improving strength of expansive soils is proved to be effective and eco-friendly as compared to other additives for soil stabilization as it is obtained from vegetable decayed matter.

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