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Influence of Terarazyme on Moderately Expansive Blackcotton Soil

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Abstract: Black cotton Soil has always posed serious problem to the infrastructures because of its swelling and shrinkage characteristics in the presence and absence of water. Light structures in rural areas of tropical India, especially in the states of Maharashtra, Karnataka and Andhra Pradesh suffer considerable swell - shrink characteristics. It is always challenging for engineers to build structures that can resist the problems created by Black Cotton soil and to make the structures functionally stable and durable. In this paper, an attempt is made to establish that Terrazyme treated Black Cotton soil performs better than untreated soil. For this purpose, locally available moderately expansive Black Cotton soil obtained from within the city of Mysore was studied for its performance with and without the inclusion of Terrazyme. The soil was tested for its index properties, compaction characteristics, Unconfined confined compression strength and permeability characteristics. Terrazyme, a non-toxic, non-corrosive, non-flammable, brown colored liquid made from fermentation of plants and extracts of vegetables and fruits was used with different dosages of 3 m^3 per 200ml, 2m^3 per 200ml and 1m^3 per 200ml. The properties of soil were established at different ages of 0th, 7th, 14th and 21st days. It has been observed that the addition of Terrazyme improved the shear strength and compaction characteristics and increased in the permeability of soil. The dosage of Terrazyme and the age of Terrazyme treated soil had considerable influence on properties of Black Cotton soil. The test results are represented in the form of tables and graphs.

Keywords: Stabilization of soil, Black Cotton soil, Dosage of Terrazyme, Age of Terrazyme, Unconfined Compression Strength, MDD & OMC and permeability.

1. Introduction

Black Cotton soil covers a large area, nearly one-third of Indian land. It occurs substantially in the central and western corridors of India. It is characterized by high volume change due to water movement. Its alternate swelling and shrinkage in the presence and absence of water respectively, results in damage to the structure in the form of cracks and undulations. Roads, conduits and light structures are most vulnerable structures to the alternate volume changes of soil on which they rest. With the need for infrastructural growth, increased lengths of highways and other buried structures, it is important that the soil on which they rest does not affect their performance. There is an urgent need to improve the soil. There are many approaches to stabilize the soil, out of which stabilization with lime is one popular method. However, availability of good lime and field stabilization in high volume are some of the challenges. There is a constant search for more improved stabilization method to treat black cotton soil.

Terrazyme is a liquid that is made from natural, non-toxic, non-corrosive, and non-flammable organic vegetable extracts. It is brown in color and perfectly soluble in water and it does not require any handling equipment. Terrazyme was created specifically to alter the engineering properties of soil. Depending on the type of soil and enzyme used, Terrazyme changes the engineering properties when combined with water and soil. These enzymes are liquid additions that work on the soil to decrease water absorption and remove gaps between soil particles for optimal compaction. The enzymes react by creating a thin hydrophobic layer and act as a water repellent. Once the enzyme reacts with the soil the action is permanent and the product is biodegradable.

It is possible that Terrazyme is used to improve the stability of soil subgrade for pavement structures, in construction of roads, fields pavements, light weight structures, earthworks and embankments resting on black cotton soil.

Several researchers have attempted to find the suitability of Terrazyme for many geotechnical applications. Varun Chaurasia et.al, (2020) carried out research on stabilization of soil using Terrazyme for Road Construction. They inferred that Terrazyme eliminates the need for granular sub-base, base course, and surface course even in high traffic situations. Utilizing Terrazyme has advantages because it has essentially no maintenance expense, affordable, efficient and

environment friendly. Saravan Muguda and Nagaraj (2019) carried out research on the effect of enzymes on plasticity and strength characteristics of an earthen construction. They highlighted the potential advantages of utilizing enzymatic stabilization to improve the volumetric stability of soil and decrease its plasticity qualities, which will lower the likelihood of crack formation. They also showed that a small quantity of enzymes would assist in strengthening the unstable earthen construction. Usha Patel et. al. (2018) showed the effect of Terrazyme on Compaction, Consistency Limits and Strength Characteristics of Expansive Soil. They revealed that liquid chemical caused a modest increase in maximum compacted density and slight decreases in optimum moisture content. Best result in UCS was found for soil treated with Terrazyme dosage of 200ml per 0.25m^3. Athira and Safana (2017) carried out a research on using Terrazyme for Road Construction and showed that Unconfined compression strength (UCC) and California bearing ratio (CBR) improved with the addition of

Terrazyme. They also inferred that the MDD increased and OMC reduced. Ramesh and Sagar (2015) carried out a research on the effect of drying on the strength properties of Terrazyme treated expansive and non-expansive soils and examined the impact of curing for periods ranging from 7 days to 60 days on the strength qualities of Terrazyme treated black cotton soil and red earth. They inferred that Terrazyme stabilization resulted in significant enhancements of engineering qualities of both red earth and black cotton soil. Considering the importance of the topic, and making sure that engineering properties of treacherous soils improve with stabilization, the present work was taken up to assess the improvement in strength and compaction properties of locally available black cotton soil with a focus on studying the permeability characteristics and interpreting the results through microscopic explanation.

The work comprised of collecting the locally available black cotton soil (virgin soil), studying all its properties such as index properties, compaction characteristics using standard compaction apparatus, strength characteristics using unconfined compression tests and determination of coefficient of permeability from laboratory permeability apparatus. Further, the Terrazyme was blended with different dosages (200ml for 3m^3, 200ml for 2m^3 and 200ml for 1m^3) and the engineering properties were determined at different ages (0th, 7th, 14th, and 21st day). Besides, the microscopic observations were made on virgin soil and Terrazyme treated soil using SEM. Fig.1 represents the methodology followed in the present work.

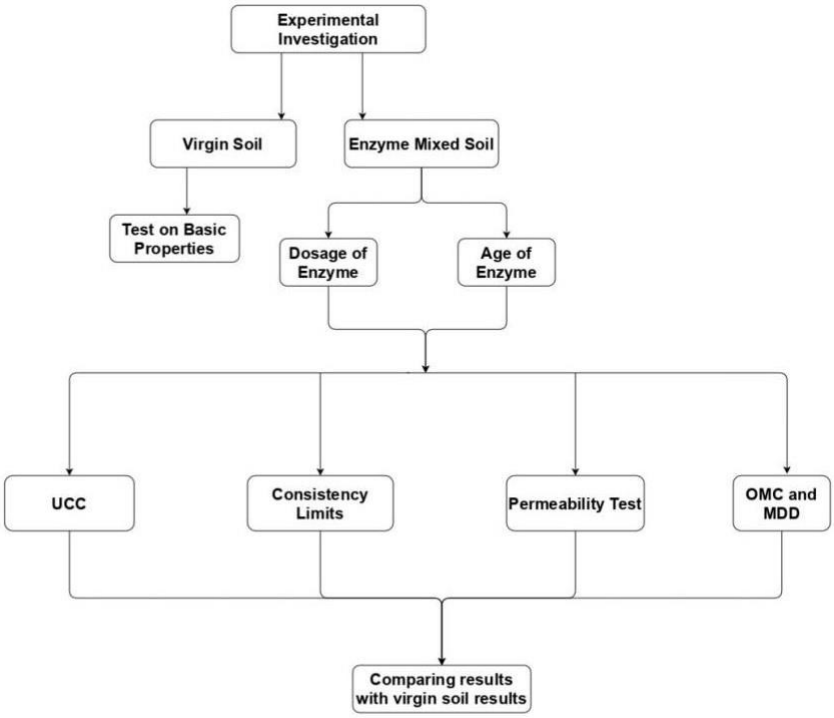


Fig.1 . Flowchart of experimental work process.

1 Results and Discussion

The engineering properties of the soil are determined by conducting various geotechnical tests on the soil as per Indian Standards IS: 2720. The index property tests including Free Swell test were performed on untreated black cotton soil and it is classified as CI.

Table 1 provides the results of index properties tests on untreated soil. Further, the tests were carried out to establish the strength, compaction and permeability behaviors of virgin (untreated) soil as compared to treated soil. The dosage of Terrazyme was varied from 200ml per $3m^3$, 200 ml per $2m^3$ and 200ml per $1m^3$ and at different curing ages of 0 day, 7 days, 14 days and 21 days.

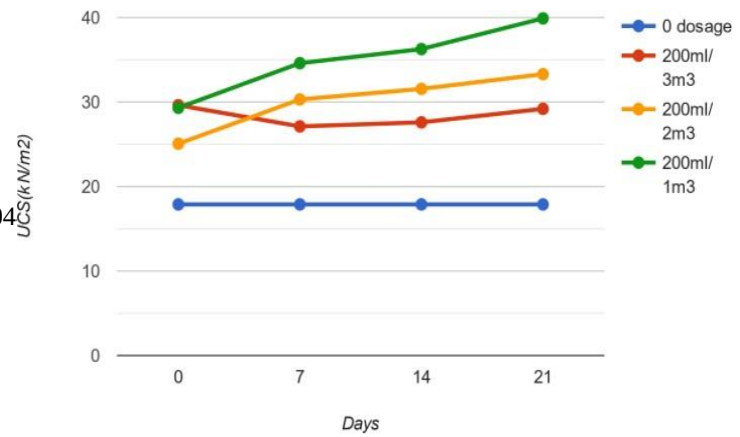
Table.1. Physical Properties of Black Cotton Soil used in the present study

Description	**Properties**
1. Particle size distribution (%)	Gravel 0% Sand 17% Silt and Clay 83%
2. Liquid limit (%)	45
3. Plastic limit (%)	23
4. Free swell index (%)	33

The results of Unconfined Compression test on the virgin soil and on soil with the addition of Terrazyme for various dosages of 200ml per $3m^3$, 200 ml per $2m^3$ and 200ml per $1m^3$ and at different curing ages of 0 day, 7 days, 14 days and 21 days are tabulated in Table 2 and presented graphically in Fig.2. It can be seen that the addition of Terrazyme increases the compressive strength and the strength is maximum at the highest dosage of Terrazyme of 200 ml per $1m^3$. Further, the strength increases with increase in age of Terrazyme treated soil.

Table.2 . Results from Unconfined Compression Test on the effects of ageand dosage of Terrazyme

Unconfined Compressive Strength (kN/m^2)				
Dosage	**0**	**200 ml / 3 m^3**	**200 ml / $2m^3$**	**200 ml / $1m^3$**
0th day	17.89	29.63	25.07	29.32
7th day	17.89	27.12	30.31	34.60
14th day	17.89	27.60	31.56	36.27
21st day	17.89	29.20	33.30	39.90



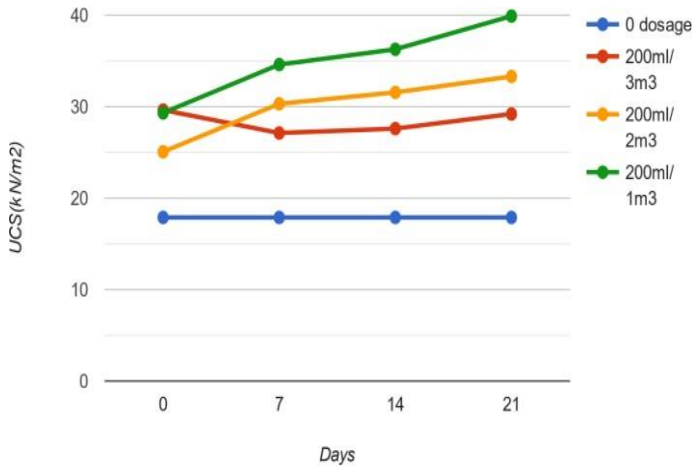


Fig.2 . Effects of age and dosage of Terrazyme on UnconfinedCompressive Strength of treated and untreated so The standard compaction test was carried out to assess the effect of addition of Terrazyme on the compaction characteristics of black cotton soil. The results of Compaction test on the virgin soil and on soil with the addition of Terrazyme for various dosages of 200ml per $3m^3$, 200 ml per $2m^3$ and 200ml per $1m^3$ and at different curing ages of 0 day, 7 days, 14 days and 21 days are tabulated in Table 3 and presented graphically in Fig.3and Fig.4. It can be seen that the addition of Terrazyme increases the Maximum Dry Density (MDD) and decreases the Optimum Moisture Content (OMC) of soil and the MDD is maximum at the highest dosage of Terrazyme of 200 ml per $1m^3$. Further, the MDD increases with increase in age of Terrazyme treated soil.

Table 3. Effect of age and dosage of Terrazyme on CompactionCharacteristics of soil

Variations in Compactioncharacteristics of soil with Dosage and age of Terrazyme								
Dosage	**0**		**200ml/3m^3**		**200ml/2m^3**		**200ml/1m^3**	
	MDD (g/cc)	**OMC %**	**MDD (g/cc)**	**OMC %**	**MDD (g/cc)**	**OMC %**	**MDD (g/cc)**	**OMC %**
0th day	1.48	21.79	1.50	19.00	1.60	9.00	1.74	5.60
7th day	1.48	21.79	1.69	15.90	1.74	8.60	1.86	6.30
14th day	1.48	21.79	1.73	13.07	1.90	9.47	2.10	7.10
21st day	1.48	21.79	1.79	12.70	2.04	10.87	2.14	8.70

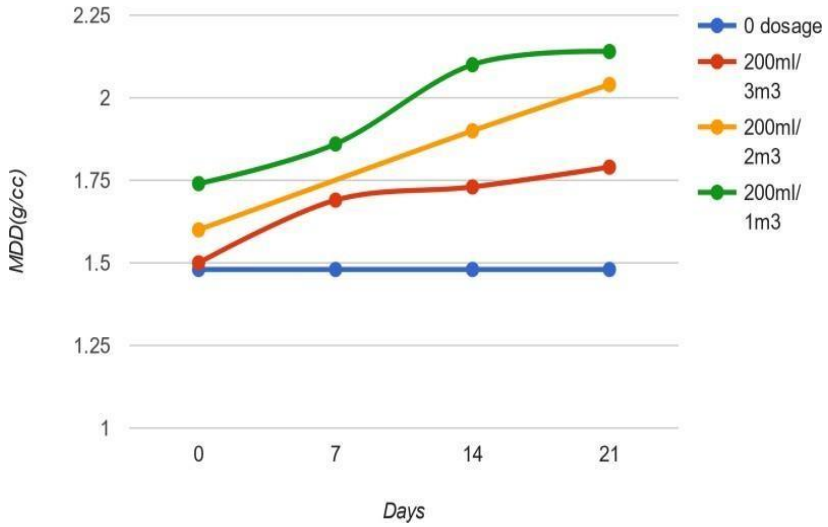


Fig.3 . Effects of age and dosage of Terrazyme on MDD of treated and untreated soil

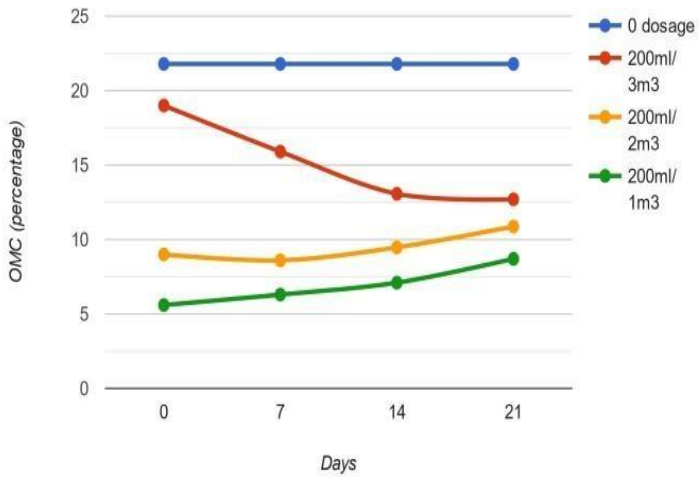


Fig.4 . Effects of age and dosage of Terrazyme on OMC of treated and untreated soil

It is convenient to believe that the amount of pore space decreases with increase in density of soil. Hence, the permeability should decrease in denser soil. The results of permeability test conducted using variable head permeability test on the virgin soil and on soil with the addition of Terrazyme for various dosages of 200ml per $3m^3$, 200 ml per $2m^3$ and 200ml per $1m^3$ and at different curing ages of 0 day, 7 days, 14 days and 21 days are tabulated in Table 4 and presented graphically in Fig.5. It can be seen that the addition of Terrazyme increases the Maximum Dry Density (MDD) coefficient of permeability of soil and the coefficient of permeability is maximum at the highest dosage of Terrazyme of 200 ml per $1m^3$.

Table 4. Effects of age and dosage of Terrazyme on Coefficient of permeability of soil

Co-efficient of permeability(cm/sec)				
Dosage	**0**	**200ml / 3 m^3**	**200ml / 2 m^3**	**200ml / 1 m^3**
0thday	0.00037	0.00041	0.00051	0.00081
7th day	0.00037	0.00050	0.00079	0.00100
14th day	0.00037	0.00076	0.00080	0.00220
21st day	0.00037	0.00079	0.00086	0.00330

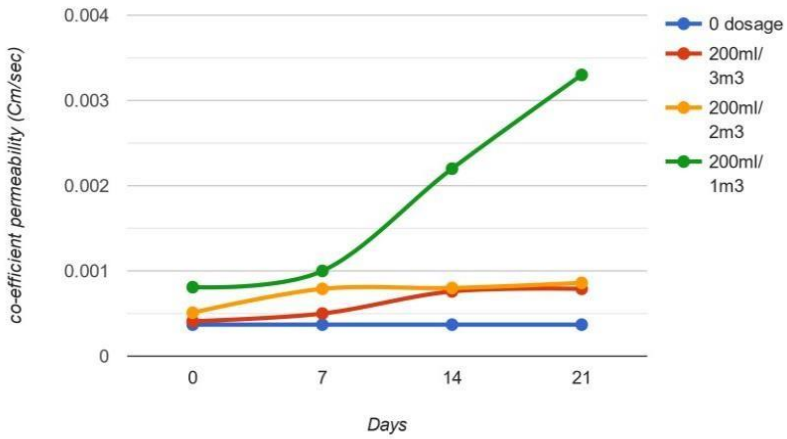
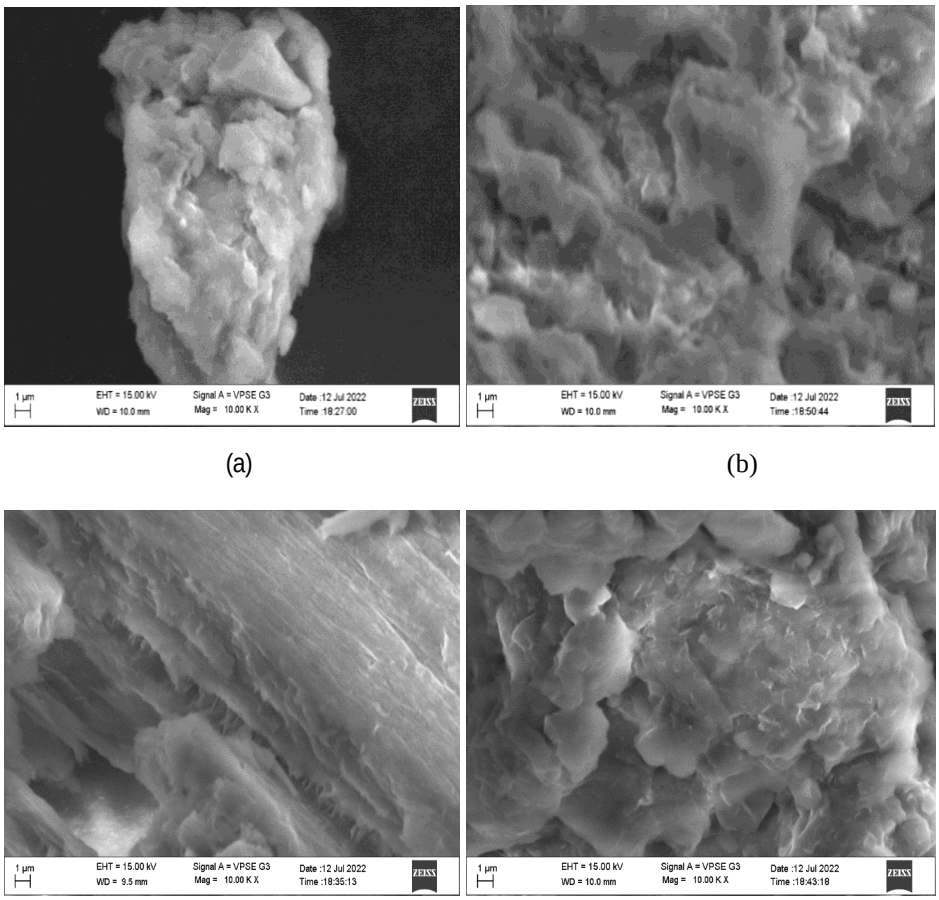


Fig.5 . Effects of age and dosage of Terrazyme on Coefficient of permeability of treated and untreated soil



(a) (b)

(c) (d)

(a) SEM image of untreated soil sample

(b) SEM image of treated soil sample with Terrazyme dosage 200mL/3m^3
(c) SEM image of treated soil sample with Terrazyme dosage 200mL/2m^3
(d) SEM image of treated soil sample with Terrazyme dosage 200mL/1m^3

Fig.6 . SEM images of treated and untreated soil samples at a magnification of 10000K

The SEM micro test was carried out to observe the specific behavior of the soil with and without the addition of Terrazyme. For this purpose, the images were taken with a magnification of 10000X. It can be seen that an individual particle without Terrazyme will have thick water cover. Further, the addition of Terrazyme causes spread in the surface area of particles and water molecules are repelled and hence the available space within the soil sample will allow for free movement of water. Perhaps, the addition of Terrazyme will reduce the moisture absorption and bring the soil particles closer. This will result in increase of the strength of soil mass. Besides, the creation of thin hydrophobic layer will act as water repellent, thereby increasing the free flow of water through the passage. It can also be seen that the spread in surface area has increased with increase in the dosage of Terrazyme.

It is interesting to note that the Terrazyme treated expansive soil showed increased density and increased permeability as well. It appears that the two properties are contradicting the behavior of the soil. Based on SEM result it can be inferred that the effect of adding terrazyme to the plastic soil is no doubt to bring the particles closer, but the passage in pore space for water flow increases because of perhaps the reduced double layer thickness.

2 CONCLUSIONS

Based on tests conducted on locally available moderately expansive clayey soil, untreated and treated with Terrazyme, the following conclusions have been drawn.

- With the addition of Terrazyme, the unconfined compressive strength of the soil increased considerably. Both dosage and age of treatment with Terrazyme play important roles
- Addition of Terrazyme increased the MDD from 18 kN/m^3 to 21.4 kN/m^3 and decreased the OMC from 21.79% to 8.70% during the compaction test.
- Addition of Terrazyme increased the permeability of the soil substantially from 3.74×10^{-3} mm/sec to 33×10^{-3} mm/sec
- There will generally be an optimum dosage of Terrazyme at which properties of soil improve to the best extent. In the present work, among three dosages considered, the best result was obtained with dosage of Terrazyme equal to 200ml/1m^3.

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