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Performance evaluation Of Bio – Enzyme Stabilized Soil Based On Laboratory Investigations: A Review

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ABSTRACT: The idea of using enzyme for stabilization in pavement construction was developed from the application of enzyme products used to treat soil in order to improve its properties. The bio – enzyme when added into the soil, increased the wetting and bonding capacity of the soil particles so as to make it more workable to compact to higher density. The use of bio – enzymes to improve the characteristics of subgrade of road pavement overcomes the available traditional methods in terms of economy and time required for stabilization. Thus, application of such innovative material to improve subgrade soil properties can become revolutionary technique and will be used worldwide. From the available literature review, it was observed that when the optimum dosage of enzymes were added into the soil both physical and strength properties of soil were improved when compared to untreated soil. The soil enzyme stabilization mostly focuses on cationic exchange between soil particles and depends upon various factors such as moisture content, clay content, type of enzyme and curing period. The previous studies shows that, use of bio - enzyme in field is soil specific and therefore it's necessary to study the effect of enzymes on soil properties before its actual use in the field.

KEYWORDS: Bio – Enzyme, Soil Stabilization, Curing Period, Strength Characteristics, Clay Content

I. INTRODUCTION

1.1 Ground Improvement

The process of improving or modifying the properties of soil so as to make it suitable for any engineering project, as a foundation bed material is known as ground improvement. In other words, ground improvement, is themodification of soil in foundation so as to provide better efficiency under design and or operational loading conditions at the construction site. Ground improvement changes soil characteristics there by permitting different types of construction operations. There is an increasing use of these techniques in the construction industry where the soils are having poor subsurface conditions. The ground improvement has been of great concern since early times. Different technologies started to develop since 17th century AD. Today, use of modern methods has made soil improvement relatively easier for the expectation in the construction industry. Ground improvement has developed into a sophisticated tool to support foundations for a wide variety of structures. When properly applied, i.e. after giving due consideration to the nature of the ground being improved and the type and sensitivity of the structures being built, ground improvement often reduces direct costs and saves time.

1.2 Bio – Enzyme as Soil Stabilizer

An enzyme is by definition an organic catalyst that speeds up a chemical reaction, that otherwise would happen at much slower rate, without becoming a part of the end product. Since the enzymes do not becomes the part of end product and are not consumed by the reaction, a

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very small amount of bio enzyme is required for soil stabilization. They are organic molecules that catalyze very specific chemical reactions if conditions are conducive to the reaction they facilitate. When added to the soil, enzymes increased the wetting and bonding capacity of the soil particles. For an enzyme to be active in a soil, it must have mobility to reach at the reaction site. Enzymes would be expected to be very soil specific. Each enzyme is specifically tailored to promote a chemical reaction within or between other molecules. The enzymes themselves are unchanged by these reactions. They serve as a host for the other molecules, greatly accelerating the rate of normal chemical and physical reactions. The enzyme allows soil materials to become more easily wet and more densely compacted.

II. II. LITERATURE REVIEW

The review of available literature based on experimental studies carried out with the use of ecofriendly material i.e. bio - enzymes to improve the properties of subgrade soils along with their concluding remarks are as follows:

A. Aboukhadra et al. (2018) [1] carried out the experimental investigation to study the impact of various dosages of commercial enzyme preparations (Terrazyme and Permazyme) on the soil strength (CBR, UCS), maximum dry density (MDD) and Permeability (k) of different Egyptian soils (Fine grained and Coarse grained). The concentration ratio of 2, 4, 6, 8 and 10 g/l was selected for Terrazyme and Permazyme and treated soil samples were tested to determine soil strength (CBR, UCS), dry density (MDD) and soil permeability (k). The results of both enzymatic treated soils were compared and are as shown in Fig. 2 for dry density and Fig. 3 for CBR value. The effect of clay content on CBR value was also checked for 0.25, 0.5 and 1% concentration of Permazyme. Further, it was concluded that value of dry density was significantly increased for fine grained soils by 1 to 6 % and the Permazyme was more efficient. The both types of enzymes showed a small decrease in dry density in sandy soil. The CBR values of fine grained soils improved 5 times the untreated soil. It was found that 18% of clay content and 0.5 % concentration of Permazyme was the optimum combination to achieve maximum CBR Value.

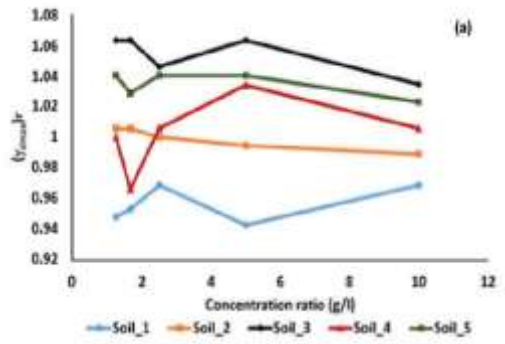

Fig. 2: Dry Densities versus Enzyme Concentration (a) Terrazyme

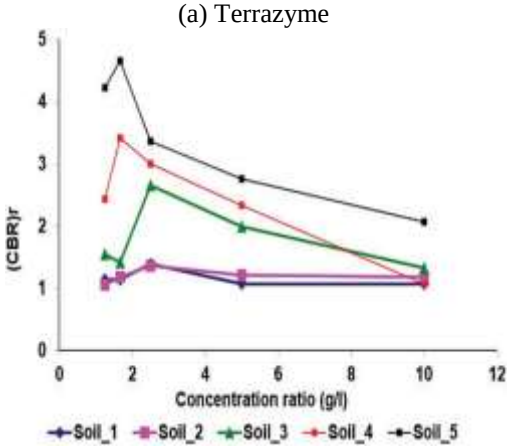

Fig. 3: CBR versus Enzyme Concentration (a) Terrazyme

G. Thomas and K. Rangaswamy (2021) [2] investigated the strength behavior of cement and TerraZyme treated soil. The soil sample was collected from a piling site at Kochi at a depth of 5 – 6 m to ensure the homogeneity of the soil sample. The Terrazyme collected from Avjeet Agencies Chennai was used as bio – enzyme and Portland Pozzolana Cement (PPC) manufactured by Ramco Cement having specific gravity of 3.05 was added to study the effect on unconfined compressive strength of untreated soil. The series of laboratory test were performed on collected soil sample and soil was classified as CH as per IS classification system. The strength behavior of soil was evaluated using a series of UCS tests in the laboratory with varying percentages of cement (0.5, 1, 1.5, 2, and 4 % by weight of dry soil) and varying dosages of Terrazyme (220 ml per 3.0, 2.0, 1.5, and 1.1 m3). Fig. 5 shows the stress strain curves for different soil cement mixtures with curing period of 1 day. However, the variation in UCS values of soil cement mixture for 1 and 7 days of curing period is as shown in Fig. 6.

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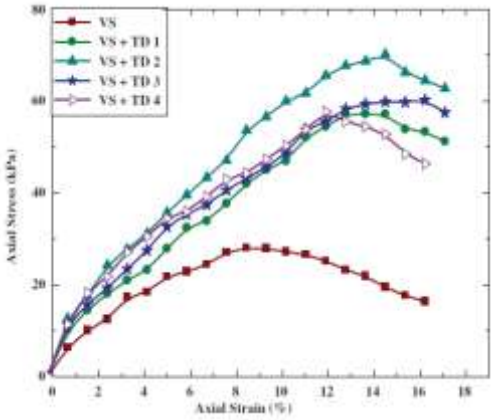

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Fig. 5: Stress Strain Curves for Soil Cement Mixtures for 1 Day Curing

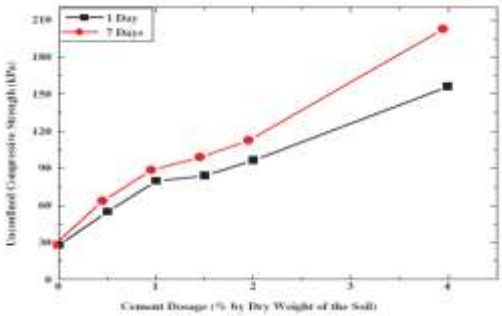

Fig. 6: Variation in UCS Values of Soil Cement Mixtures for different Curing Period

For enzyme soil stabilization, a series of tests were performed on soil – Terrazyme mixtures without the presence of cement content to investigate the effect of Terrazyme alone on strength improvement of clay soil. The Terrazyme dosages in the range of 0.04 to 0.11 ml/kg are injected into the OMC (Optimum moisture content) of clay soil and mixed thoroughly into the clay to make four combinations of soil - Terrazyme mixtures. It was aimed to obtain the optimum dosage of Terrazyme corresponding to maximum UCS strength. In this treatment, curing period of 1 to 28 days was selected to understand the effect of curing on sustained strength improvement. Fig. 7 and Fig. 8 show the variation in stress strain relationship of soil Terrazyme mixture for 1 and 7 days respectively. [3].

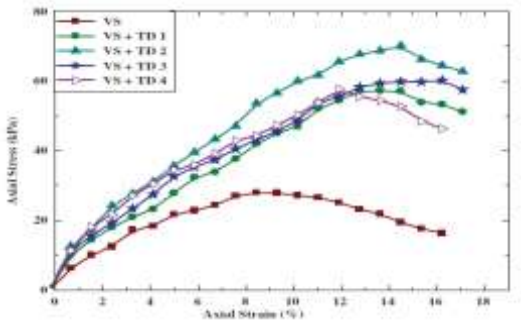

Fig. 7: Variation in UCS Values of Soil Terrazyme Mixtures for 1 Day of Curing Period

From the experimental investigations, it was observed that both cement and Terrazyme were effective in improving soil UCS with curing period. For curing periods of 1 and 7 days, the maximum increase in UCS of cement treated soil (4% by weight of dry soil) was around 457.34 % and 623.51 %, respectively. For a dosage of 200 ml/2.0 m3, the maximum increase in UCS of Terrazyme treated soil was around 272 %

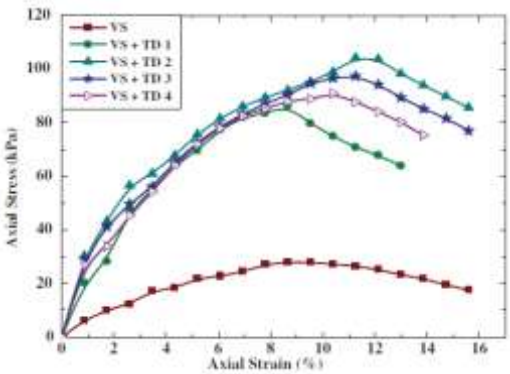

Fig. 8: Variation in UCS Values of Soil Terrazyme Mixtures for 7 Day of Curing Period

R. Renjith et al. (2020) [3] carried out optimization of enzyme based soil stabilization of lean clay (CL) with the use of Eko soil as stabilizer. The soil samples were prepared in all stages of tests at various dilution mass ratio (DMR) and application mass ratios (AMR), which is the ratio of the diluted additive to dry weight of soil. Four DMRs (1:100, 1:300, 1:500, and 1:900) and AMRs (1%, 3%, 5%, and 7%) were tested for strength in the form of UCS and CBR. The soil was prepared to OMC–AMR þ 2% and allowed to reach equilibrium in a sealed container for at least 16 h. The 2% moisture was to compensate for the unavoidable moisture loss from the sample during this preparation process. Having obtained the required mass from DMR to attain the OMC, the diluted stabilizer was added to remoistened soil and

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mixed using a mechanical mixer as well as by manual means to attain a high degree of homogeneity before compacting it for CBR and UCS tests. Fig 9 and Fig 10 shows the variation in CBR and UCS values for different DMR and AMR of Eko stabilized lean clay.

From the experimental results, it was observed that both CBR and UCS values increased with increase in application mass ratios. However, it was concluded that AMR of 7% at DMR 1:500 could ensure easier and uniform mixing of the additive in thesoil.

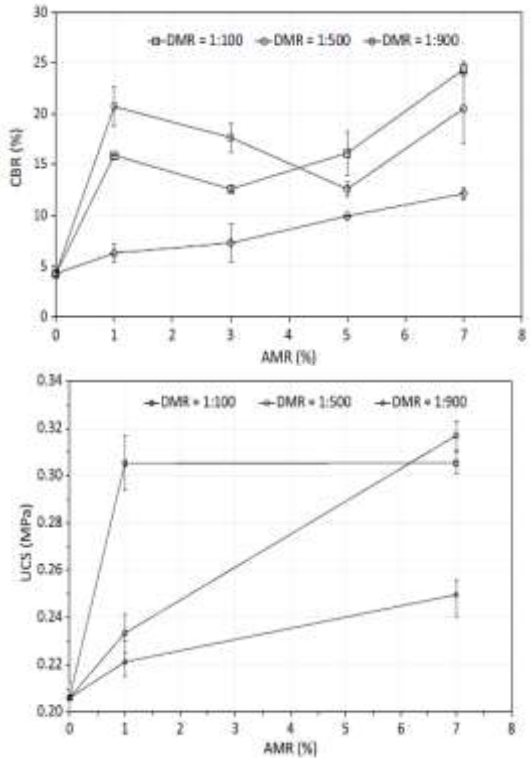

Fig. 9: Variation in CBR Values of EkoFig. 10: Variation in UCS Values of Eko Stabilized Lean Clay Stabilized LeanClay

S. Das and M. Maharana (2017) [4] studied the behavior of expansive soil by enzymatic treatment with Terrazyme (Bio-enzyme). The experimental investigation was carried out with varying dosage of Terrazyme as 200 ml per (3.5 m3, 3 m3, 0.5 m3, 0.25 m3, 0.15 m3 and 0.075 m3) of soil. The treated soil samples were tested in laboratory and results were compared with untreated soil. It was observed that UCS value increased more than 138 % when compared to natural soil. The cohesion value was increased by 100% and friction angle was normally about 10- 40 higher that of untreated soil. It was also concluded that there was a continuous improvement in the strength (CBR) values with increase in enzyme dosages. S. Muguda and H. Nagraj (2019) [5] carried out the experimental programme to study the impact of enzymes on characteristics of soil and also check the suitability of treated soil to be used in preparation of an earthen construction material such as CSEBs (Compressed Stabilized Earth Blocks), adobe blocks and rammed earth construction. The study was carried out to enhance the properties of untreated soil with variation in dosages of Terrazyme as 200 ml/3.5 m3, 200 ml/2.5 m3 and 200 ml/2.0 m3 and 200 ml/1.5 m3. From the results obtained after treatment to natural soil, plasticity properties (Liquid, Plastic and Shrinkage limits) of treated soil were changed from 42.2 % to 38.2 %, 22.8 % to 26.0 % and 21.3 % to 24.3 respectively for the optimum dosages of 133.33 ml/ m3 and curing period of 60 days. The increase in strength due to addition of enzyme might have changes the soil to more flocculated structure. Furthermore, it was discovered that sealed soil curing was more successful than wet soil curing for increasing the strength of enzyme-treated soil. As a result, the performance of enzymatically treated soil influenced by the method of curing chosen in the field.

T. Khan et al. (2020) [6] studied the performance of sedimentary residual soil mixed with 10 % bentonite when applied with three enzymes named as Terrazyme (TER), Earthzyme (EAR) and DZ1X (DZ). Further, three different clays including Bentonite (CH), Illite (CH), and Kaolinite (CL) were also treated with enzymes to understand the effect on their strength characteristics. The bentonite treated soil was classified as CH with clay fraction of 36 %. The dosages of enzymes were prepared at three dilution ratios (DR) of 5/1000, 1/1000 and 1/1000 for DZ, EAR and TER respectively with application ratios (AR) of 1/7035, 1/55275 and 1/41875. The treated soil samples (Bentonite + Enzyme) were tested for swell and UCS values at water content equal to OMC – AR/DR + 1 % and cured for four months. The additional 1% was safety against loss of moisture during preparation of soil samples. The swell potential before and after treatment with different dosages of enzymes was compared (Fig. 11) and found that improvement was maximum for (EAR – D5) samples where it reduced from 6.63 % to 6.48 %. The maximum increase in UCS of soil was observed 5 % for EAR – D5 and TER –D5 (Fig. 12).

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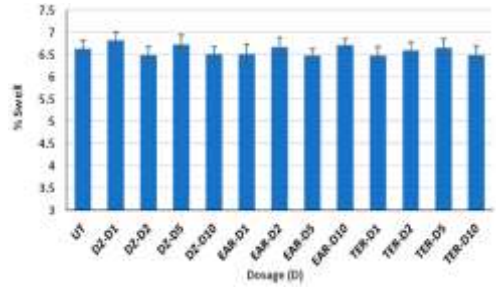

Fig. 11: Swell Potential of Treated Soil (Bentonite + Enzymes) for Varying Dosages

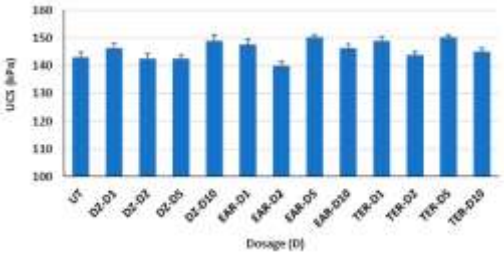

Fig. 12: UCS of Treated Soil (Bentonite + Enzymes) for Varying Dosages

Reddy et al. (2020) [7] studied the effect of bio-enzymatic treatment on soils of different parts of Karnataka (BC, Lithomargic and locally available) soil to make it convenient for subgrade material of road pavement. The dosages of Terrazyme were calculated from the values of dry density obtained from compaction test which further finalized as 200 ml for 2.0, 2.5 and 3.0 m3 of soil. A series of tests were performed on treated soil to understand the effect of different dosages of enzymes on compaction characteristics and UCS value of (BC, Lithomargic and locally available) soil. The highest UCS value of BC soil was attained for 15 days of curing for all dosage levels, and it is observed to be double that of untreated soil, according to the experimentalfindings

S. Chandrakaran et al. (2017) [8] experimentally examined the impact of enzymatic lime on properties of soil. The investigation was carried out for the variation in soil CBR with enzymatic lime. The Kaolinite natural soil procured from Kerala (Pantheerancavu) was used to prepare soil specimens further to stabilized with quick lime and bio-enzyme (Terrazyme) obtained from commercial suppliers in Chennai. The effect of enzymatic lime was further checked for soil specimen having 40% and 60 % of clay fines. After the samples were examined for different dosages of lime and enzyme, the optimum enzyme lime mixture was determined to be 70 mL/m3 of enzyme and 1.75 percent of lime. Under dry conditions, CBR values increased by upto 5 times when treated with lime alone and by upto 3 times when treated with enzyme alone. In a dry CBR test, an increase of more than 6 times was observed when treated with enzymaticlime. However, the result of two weeks curing demonstrated that with lime and enzyme stabilization, the improvement was less than 2 times, whereas with enzymatic lime stabilization, the improvement was approximately 4 times. The enzymatic lime stabilizer was found to be more efficient in soil samples with higher clay content.S. Khushwaha et al. (2018) [9] carried out stabilization of red mud using Eko soil enzyme for highway embankment. The Eko-Soil Enzyme is a synthetic replication of enzymes contained in that effective natural building material, termite saliva. It reacts with clay particles in soil to accelerate a standard compacting process to create a surface with concrete-like strength. The variation in strength characteristics were determined by treating the red mud with varying dosages of Eko enzyme from 1 to 5 % with curing period of 7, 28, 45 and 90 days. The samples were prepared at respective optimum moisture content obtained from series of compaction testtest as shown in Fig. 13. The CBR test results show that curing period play an important role in strength gain of enzyme treated soil. Fig. 14 and Fig. 15 shows the variation of CBR and UCS values with varying dosages of enzyme.

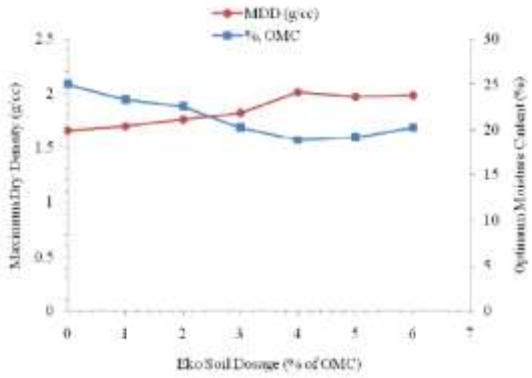

Fig. 13: Compaction Characteristics of Enzyme Treated Soil

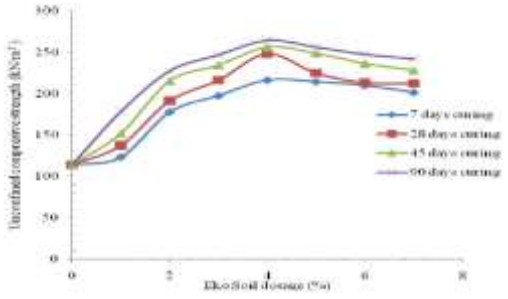

Fig. 14: UCS Values of Enzyme Treated Soil

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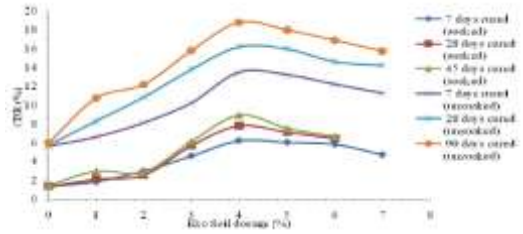

Fig. 15: CBR Values of Enzyme Treated Soil

III. CONCLUSION

The following are the general conclusions made from the available studies based on soil enzyme stabilization:

The soil enzyme stabilization is effective in improving the physical and strength properties of subgrade soil and can be effectively used in the construction of road pavement.

The soil enzyme stabilization is more effective and economical when compared with traditional methods.

The bio – enzyme is proven to be an environmental friendly material which can effectively reduce the swelling potential of high compressibility clays.

The soil enzyme stabilization depends upon various factors such as type of enzyme, clay content, curing period and dosage of enzyme.

The soil enzyme stabilization is proven to be more effective in case of cement and lime stabilized soil when compared with enzyme alone.

The use of enzyme is soil specific and thus it is necessary to study the effect on properties of soil before its use in the field.

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