A Review on Terrazyme as Pavement Enhancement Approach:

Palakpreet kour¹, Amanpreet Tangri², Mohammad Farhad Ayazi³
¹³M.E Research Scholar, Chandigarh University, Gharuan-140413, Mohali, India,
²Assistant professor, Department of Civil Engineering, Chandigarh university, Gharuan-140413, Mohali, India,
Palakpreet242@gmail.com, amanpreet.civil@cumail.in, farhad.farhamand1395@gmail.com

Abstract: During construction, Engineers often face difficulty related to the stability of soil with or on which the structure is being constructed as the unstable soil cannot not withstand the loads imposed over it. Since the layers of pavements distributes the load evenly over the subgrade, the design of pavement layer is very much dependent on the strength of the subgrade soil over which they are to be laid. So, there is an urgent need to improve the properties of subgrade. An effort to treat the earth with an enzyme that proves very much advantageous for engineering purposes. It is a natural solution which is generated by the enzymatic action on fruits, edibles, saccharine and water by means of fermentation. In this research, a bio-enzyme labelled as Terrazyme is being utilized that significantly improves the properties of soil. Terrazyme being cost effective, efficient, non-toxic, non-inflammable increases the stability by accelerating the enzymatic reactions between the argil and cations(organic) and accelerates the cationic interchange operation to lower down the diffused double layer thickness. The paper deals with all the information about terrazyme including its working mechanism and different properties of soil. It has been investigated that on incrementing the dosage of terrazyme in test sample, notable improvement in the value of UCS and CBR value of soil is observed.

Keywords: Bio-enzyme, California Bearing Ratio, Stabilization, Terrazyme, Unconfined Compressive Strength.

1. Introduction

The chemical or physical treatments which increase or maintain the stability of soil by improving engineering properties is defined as soil stabilization. In many parts of India, soil consists of high silt content, and when the deficient quality of soil is accessible at building sites, best choice is to alter its properties to meet the desired requirements. The objective behind employment of enzyme for soil enhancement evolved from exercising the enzyme products used for improving horticultural applications, so an alteration to a process manufactured a substance which was acceptable for stabilization of low-quality subgrade for road traffic. Hence, on being applicable to soil, they increase the wetting and binding properties of soil particles. It is very essential for the soil stabilization process to be cost efficient, eco-friendly and yield optimum results. Stabilization by the addition of bio-enzyme is an innovation which in past has given economical solutions for improvising subgrade material in pavement construction. One such organic enzyme that is terrazyme, which is been
extensively used for modifying the soil in road construction. In the recent study, effect of its addition for improving California bearing ratio and unconfined compressive strength values of soil has been analysed. The major objective of the review is to explore the effects of terrazyme on several properties of soil.

2. Materials

2.1 Terrazyme

A browned colour natural solution formulated by using fruit and vegetable derivatives. It is easily mixed with water and for ideal results it should be diluted with OMC of that soil. Terrazyme help in decreasing the bulging capacity of soil particles and lower down its permeability. This in turns helps in improving the stress carrying capability of soil as well as help in reducing the road thickness and conservation or repair cost, See Table 1.

| Colour          | Dark Brown                   |
|-----------------|------------------------------|
| PH              | 3.5                          |
| Specific gravity| 1.414                        |
| Rate of Evaporation | Alike water               |
| Odour           | Smell like molasses          |
| Flammability    | Inflammable                  |
| Solubility      | Infinite                     |
| Boiling point   | 212°F                       |

2.2 Mechanism of Terrazyme

Terrazyme is an agent which is acting on the surface and converts the water loving nature of clay and lime material to water hating. The outcome of terrazyme is due to association (reaction) between the clay and organic cation which forms the thin protective coating around the clay particle and turns it to water repellent by neutralizing its negative charge. It acts to lower down the space midst the soil particles and reduces the soaked water in the soil for utmost compaction as terrazyme does not get substituted by water therefore reduces the aptness of the expansive clay to bulge. This is how the particles of soil come closer and attain greater compaction with lower compactive effort.

So, a reaction between terrazyme and clay establishes a cementious compound called Calcium Silicate Hydrate which tends to transmit firmness to the untreated soil, see figure 1.

\[ H_2O + CLAY \xrightarrow{\text{TERRAZYME}} \text{Calcium Silicate Hydrate} \]
Practical application of terrazyme in India:

- In Nasik, Maharashtra, terrazyme has been used on black cotton soil to construct a state highway.
- Some trial roads are also constructed in states of Tamil Nadu, Kerala and Karnataka.
- In Maharashtra, PWD department has constructed two roads using this enzyme and the cost reduction of 18-26% has been reported.

Outcomes of terrazyme on soil properties:

The results of terrazyme are varying on different soil types having varying dosages. Some of the properties of soil after its addition are as follows:

UCS: It stands for Unconfined Compressive Strength. Under unconfined condition, the maximum axial compressive stress withstood by the cylindrical sample of soil is the UCS of a give soil mass. In order to determine the effects of terrazyme on soil, it is necessary to know its changes on UCS. It has been analysed that increasing amount of terrazyme in a given soil mass, there is an outstanding increment in the UCS value of soil to a greater extent.

CBR: It stands for California Bearing ratio. Force per unit area essential for penetrating a mass of soil sample with a standard piston for the corresponding penetration of standard sample. Basically, done for estimating the subgrade strength in pavement. From the study, the addition of terrazyme had been a remarkable improvement in the values of samples since the increased compaction will create stronger bond between soil particles, which results in resisting penetration.

2.3 Consistency Limits

The moisture content whereupon soil alters its state is known as consistency limits. It has been analysed that by increasing the amount of terrazyme, Liquid and Plastic Limit values reduces significantly along the denseness of the soil. Since, the particles of clay bonds after enzyme activity the soil alters its state at less moisture content.

3. Review of literature

Various researchers have done research on different types of soil by addition of terrazyme. The review of the literature is described in the following tabular form, see table 1.

| S.no | Variables | Studies | Outcomes |
|------|-----------|---------|----------|
| 1    | 0.25,0.5,1,1.25,1.5,1.75, of terrazyme was added to 5 kg of expansive black cotton soil for 1 and 7 days of curing | UCS | - The ideal value required for enhancing the UCS of BCS was observed at 1ml/5kg.  
- With the increase in terrazyme dosage, there was significant increase in the value of UCS up to 200%. [1] |
| 2    | Sample of BCS was used. Dosage as 200ml in 3, 2.5, 1.5m of soil sample at 0, 7, 14, 21, 28 day curing period. | CBR, UCS | - LL decrease from 61.40% to 56.49% at D9, dosage OMC decreased from 23% to 20.40%  
- MDD decreased from 1.486g/cm^3 to 1.633g/cm^3  
- UCS increased from 3.53kN/m^2 to 8.86kN/m^2 |
CBR increased from 1.19% to 5.80% and there is percentage increase of 387%.\textsuperscript{[2]}

| 3 | 200ml of terrazyme was added to 1.5, 2.0, 2.5, 3.0m\(^3\) of Black Cotton Soil. 200ml of terrazyme was added to 2.5, 3.0, 3.5, 4.0m\(^3\) of soil Red Earth. | UCS CBR Atterberg limit | - Properties of BCS was enhanced by treating it with 200ml/2m\(^3\) of soil.  - The optimum value for red earth was considered as 200ml/m\(^3\). - UCS of both BCS and red earth increased on drying rather than curing them in a laboratory desiccator.\textsuperscript{[3]} |
| 4 | Terrazyme dosage of 200ml was added to 0.5, 0.75, & 1m\(^3\) of Black cotton soil and Red Earth. | L.L. Plasticity Index UCS | - With increased dosages, L.L., Plasticity index decreases. - Best results were observed with 2nd dosage of 200ml/0.75m\(^3\) at 21 day curing period.\textsuperscript{[4]} |
| 5 | Terrazyme Dosage as 500ml/m\(^3\), 700ml/m\(^3\), 1000ml/m\(^3\) Of random soil sample. | CBR | - Strength increased with increased dosage of terrazyme. - Best result in 3\(^{rd}\) dosage with 2 week curing period.\textsuperscript{[5]} |
| 6 | Laterite soil with varying dosages at 0, 7, 14, 28 days period. | UCC CBR Standard proctor | - UCC value of treated and untreated sample at 28 days curing increased by 166.3%. - Increased in CBR value by 139.32% after 28 days curing. - With increased in terrazyme dosage, the OMC value decreased by 14.8% and MDD value increased by 61.59% after 28 days curing.\textsuperscript{[6]} |
| 7 | Study of terrazyme on various soil properties. | CBR UCS Consistency limits Permeability OMC | - on application of terrazyme, the strength of soil got enhanced i.e CBR & UCS values improved. - OMC and Consistency Limits values decreased - Permeability decreases by making soil water resistive.\textsuperscript{[7]} |
|   | Local soil with enzyme dosage as 200ml/0.075,0.15,0.5,2,2.5,3,3.5m³ of soil sample. | Consistency limits | Compaction UCS CBR Triaxial | -For higher dosage of 0.3 LL, PL, PI decreased by 47%,28%,24%. -OMC and MDD at 0.08% Optimum dosage is 16.4kN/m² 19% respectively -UCS increased by more than 138% -From triaxial test cohesion and friction angle is found to be 100% and 1°. 4° higher than virgin soil. CBR value increased by 208%.[8] |
|---|---|---|---|---|
| 8 | Black cotton soil Terrazyme was added by replacing 1%,2%,3%,4% of OMC for soaked and unsoaked samples. | Shear strength CBR | -Shear strength increased from 17.65 kpa-78.48 kpa at 7 day curing -CBR value of soaked and unsoaked sample increased with percentage increase of 104.32 and 451.87.[9] -Cohesion increased with percentage increase of 463.56.[9] |
| 9 | 200ml of terrazyme was added to 1.5,1,0.5 m³ of soil sample 0,7,14,21,28 days of curing period. | UCS CBR | -The optimum value of terrazyme for CBR and UCS was obtained at 0.2ml/kg. -Terrazaye dosage of 0.2ml/kg of UCS by 375% -The value of CBR was increased at 0.2ml/kg by 185.32%. [5] |
| 10 | OMC was replaced by increasing percentage of terrazyme as 1%,2%,3%,4% for 4 and 7 days | CBR Shear strength Triaxial test | -Shear strength increased by increasing percentage of terrazyme by 410% for 4 day curing. -CBR value of soaked and unsoaked sample was increased by 104% -Triaxial test results shows that with increasing percentage the %age increase in shear strength was 451.87% and in cohesion was 463.50%. [10] |
| 11 | Expansive soil Enzyme dosage as 0.029 kg/ml in 3.5kg, 0.039 kg/ml in 3kg, 0.041kg/ml in 2.5kg for 0.3,7,14 day curing period | CBR | -The unsoaked value of CBR was enhanced by 84% with D₁ dosage at 14 day curing. -Strength increased with increase in dosage.[11] |
The Possible benefits of terrazyme includes: enhances the longevity of surface course and lowers the expansive i.e bulging properties of soil [13,14]. Enhances the weathering resistance and improving stress bearing capacity of soil. Reduce construction expense by about 20-40% due to the minimization of transportation material and reuse of in-situ material [15–18].

4. Conclusion and Future Scope

After doing a review of various research papers we can conclude that terrazyme is an effective technique of ground improvement. It gives better performance in field and ultimately ensures durability and maintenance of free pavement. It is an eco-friendly, non-toxic, natural and organic material that does not cause any harm to humans, animals or vegetation. Even though it is an expensive material, it is economical due to its optimum results and permanent application. Moreover, the base or subbase layer can be eliminated, so the total cost of the project reduces considerably. It can be handled easily without the need of gloves and masks. It makes the soil waterproof by making it impermeable. The various conclusions extracted from the above study are:

- Employment of terrazyme improves the strength of soil, obvious from the rise in CBR and UCS results.
- OMC and Atterberg limits of sample of soil decreases because it improves the density of soil by reducing the voids between the soil particles.
- Renders soil water repellent by reducing pervious nature of soil.
- It’s bonding with cohesive soil, makes it essential to grasp the clay content of soil.
- With the rise in time, the results of terrazyme improves.
- Terrazyme proves to be the smarter material and could play a pivotal role in coming years hence could also be most feasible in construction works.

The various limitations of usage of terrazyme includes; Due to the increase in density of soil as a result of enzymatic reaction, Consistency limits reduce. If being used in excessive amounts, formation of cracks may take place and Uns suited for small -scale construction purposes.

4.1. Future scope

- The effect of terrazyme with other bio-enzymes can be studied.
- Effect of terrazyme on varying dosages can be analysed on varied duration
- Due to enzymatic formulation from locally available raw materials, it can be a medium of research in various institutes.
- Various inventions can be identified in order to fit the applicability of soil stabilization.

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