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A Study on Soil Stabilisation using Bio-Enzyme

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Abstract—*Engineers often faces problem with soils which do not possess sufficient strength to support the loads imposed upon them either during construction or during service life of the structure. Many areas of India consist of soils with high silt contents, low strength and minimum bearing capacity. These negative soil performance characteristics are generally attributed to the nature and quantity of the fines present in the soils. There are various methods that could be used to improve the performance of poor quality soils. The choice of a particular method depends mainly on the type of soil to be improved, its characteristics and the type and degree of improvement desired in a particular application. Recently bio- enzymes have emerged as a new chemical for soil stabilization. Bio- enzymes are chemical, organic and liquid concentrated substances which are used to improve the stability of soil. Bio-enzyme is convenient to use, safe, effective and dramatically improves road quality. Stabilisation of soils is an effective method for improving the properties of soil and pavement system performance. The objectives of any Stabilisation technique used are to increase the strength and stiffness of soil, improve workability and constructability of the soil and reduce the plasticity index. In this paper there is a discussion about quantitative changes in the geotechnical properties of the alluvial soil with different dosage of bio-enzymes.*

Keywords: *Soil-stablization, Bio-Enzyme, Plasticity index, stiffness.*

1. INTRODUCTION

Extensive research has been conducted studying the application of traditional stabilization additives such as lime, cement and fly ash. However, engineering research studying non-traditional stabilization additives such as enzymes are less documented. The U.S. army conducted soil stabilization by use of additives as early as the 1940 in the construction of airfields for heavy bombers. The US army conducted extensive research on soil stabilization for roads and air fields. Soil stabilization techniques for civilian uses are currently a common practice with applications for roads and foundation performance improvement. The stabilizers were tested on a highly plastic fat clay material and were based on the unconfined compressive strength test. Their results indicated that the undrained shear strengths of the enzyme products were 21 % higher than the control specimens this suggested that the products in the concentrations used, added a stabilizing quality to the relatively dry specimens. Bio-enzyme is by definition an organic catalyst that speeds up a chemical reaction, that otherwise would happen at much slower rate, without becoming the part of the end product. Since the enzymes don't become the part of the end product and are not consumed by the reaction, a very small amount of bio-enzyme is needed for soil stabilization. There are various types of bio-enzymes available in the market as soil stabilizers such as Terrazyme, Renolith, Permazyme, Fujibeton. Terrazyme is a natural, non- toxic, non-flammable liquid, formulated using vegetable extracts and accepted all over the world as a sound and resourceful road building practice, which completely replaces the conventional granular base and granular sub base, it emphasizes on strength, performance and higher resistance towards deformations. Terrazyme is specially prepared to increase the engineering properties of soil. The use of Terrazyme enhances whether resistance and also increases load bearing capacity of soil.

2. SOIL STABILISATION

Stabilization in a broad sense incorporates the various methods employed for modifying the properties of a soil to improve its engineering performance. Stabilisation is being used for a variety of engineering works, the most common application being the construction of road and air field pavements. It is the process of improving the engineering properties of soil by mixing some binding agent thus binding the soil particles. There are many methods of soil stabilization. Some of the conventional methods of soil stabilization can be mechanical, cement, lime, bituminous, thermal & electrical, mechanical stabilization is the simplest method of soil stabilization, The decreasing availability and increasing cost of construction materials and uncertain economic climates force engineers to consider more economical methods for building roads. An obvious solution is to use locally available materials. Soil Stabilization helps in reducing the permeability of soils ,increases bearing capacity of foundation soils ,also improve the natural soils for the construction of highways and airfields.

3. BIO-ENZYMES AS SOIL STABLISERS IN ROAD CONSTRUCTION

Bio-road products are a basic fermented and formulator of soil treatment products that create enzyme stabilisation of base, sub base and sub grade soils used in road construction. We have found from our extensive worldwide experience that enzyme stabilization is effective when the soil contains Bio-road products are a basic fermented and formulator of soil treatment products that create enzyme stabilisation of base, sub base and sub grade soils used in road construction. We have found from our extensive worldwide experience that enzyme stabilization is effective when the soil contains a sizable fine grained component. Bio-enzyme is a natural, non-toxic, non-flammable, non-corrosive liquid enzyme formulation fermented from vegetable extracts that improves the engineering qualities of soil, facilitates higher soil compaction densities, and increases stability. The bio-enzyme attaches to the microbes present in the soil and causes them to come together by forming tight covalent bonds with each other. Upon bonding these microbes lower the surface tension of the water, which promotes fast and through penetration and dispersal of moisture.

In clay water mixture positively charged ions (cat-ions) are present around the clay particles, creating a film of water around the clay particle that remains attached or adsorbed on the clay surface. The adsorbed water or double layer gives clay particles their plasticity. In some cases the clay can swell and the size of the double layer increases, but it can be reduced by drying. Therefore, to truly improve the soil properties, it is necessary to permanently reduce the thickness of double layer,

By utilizing fermentation process specific micro organism can produce stabilizing enzyme in large quantity. These soil stabilizing enzymes catalyze the reactions between the clay and the organic cations and accelerate the cationic exchange without becoming part of the end product.

H_20 + clay + Terrazyme → Calcium Silicate hydrates

4. TERRAZYME, A BIO-ENZYMETIC SOIL STABILIZER

Terrazyme is a natural, non-toxic liquid, formulated using vegetable extracts. Apart from being a concept accepted the world over as a sound and resourceful road building practice, which completely replaces the conventional granular base and the granular sub-base. Terrazyme are useful in constructing Highways, Rural Roads, and Townships etc. The soils treated with Terrazyme renders improved density values by reducing the void ratios to a large extent which results in an overall improvement in the CBR.It facilitates higher soil compaction densities, and increases soil strength and stability for lasting roads. reduces fuel usage associated with frequent, short interval road repairs. Terrazyme was developed to assist engineers with the removal of adsorbed water in materials in order to achieve maximum density with less mechanical effort and to prevent the absorption of water that results in permanently stabilized construction materials. Terrazyme is a cation reactive synthetic compound that forms a protective coating on oily cay layers on the surfaces of soil and clay particles. It reduces ion mobility and ion exchange and simultaneously makes the material hydrophobic by eliminating the absorption of water.

5. STUDY AREA AND TEST RESULTS

Bihar is a landlocked state in the middle of gangetic region with major rivers passing through it. The area of the state is 94,163sq.km.Improvement in the transport infrastructure and more particularly the rapid development of the road network in the state could provide the requisite impetus for its economic development. However the existing road network in Bihar is around 59159 km (Source RCD Bihar) The network is inadequate both in capacity and quality due to various regions among which major is economic and design problems. The description of road statistics in India in general and in Bihar in particular is as follows. The description of road statistics Bihar consists of NH (3734 Km^2),SH (4857 Km^2),MDR (9030 Km^2) and ODR (20190 Km^2) .Large part of Bihar are covered by the alluvial soils. The thickness of these soil deposits are over 100m.The deposits have alternating layers of sand, silt and clay. There is a great deal of variation in thickness of these layers and their horizontal development. The alluvial deposits extend from Assam in the east to Punjab the west.

The soil to be tested was taken from NIT Patna campus and tested first for its native properties then again underwent tests after dozing with bio-enzyme in five different proportions. The overall testing programs were conducted in two phases. In the first phase, the geotechnical characteristics of local soil were studied by conducting laboratory tests. In the second phase, local soil was mixed with Terrazyme with different dosages i.e. 3.5m^3 per 200 ml, 3m^3 per 200 ml, 2.5m^3 per 200 ml. Various test were performed and the results are as shown the fig. 1 i.e Unconfined compression test. Sample Preparation for the test is shown in Table 1.These test were carried out on cohesive soils and stabilized soil specimens. This test may be considered as a special case of the tri axial compression test when the lateral confining pressure is equal to zero.

Table 1:- Sample Preparation for the test

Penetration, mm	Standard load, kg	Unit standard load kg/cm^2
2.5	1370	70
5.0	2055	105

Soil	Enzyme	Dosage	Curing period	Test performed
Alluvial soil(CL)	Terrazyme	200 ml Per 3.5, 3, 2.5, m^3 soil.	0, 7, 14, 21 and 28 days.	Atterberg's limits,UCS, CBR, etc

Cylindrical test specimen of diameter 38 mm or more, with height to diameter ratio 2 to 2.5 are prepared using either undisturbed or remoulded samples. Graphs(Fig. 1 and Fig. 2) have been plotted in between UCS and doses of bio enzymes for 30 days.

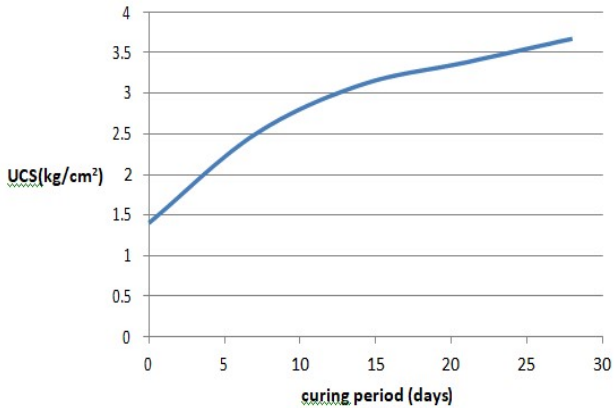

Fig. 1: Graph UCS v/s Bio enzyme dose (for 30 days).

Further ,CBR test was carried out as per the guidelines of Indian Roads congress (IRC) and the values obtained for the stabilized soil samples are tabulated below(table 2) for different curing period.

Table 2: CBR Test Performed (As per IRC)

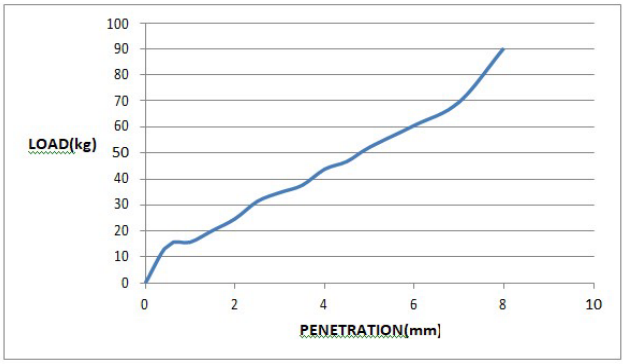

Fig. 2: Graph showing load vs. penetration curve for original soil sample (without Terrazyme)

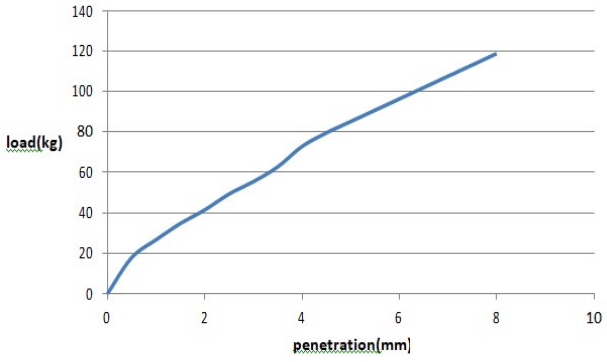

Fig. 3: Graph showing load vs. penetration curve for mixed soil sample (with Terrazyme)

6. RESULTS AND DISCUSSION

The CBR test was carried out for the original soil sample as well as stabilized soil sample according as IS: 2720. The value of CBR for original soil sample was 2.53% for soaked condition and 4.14% for unsoaked condition. The value of CBR increases dramatically on dosing with bio-enzyme. The graph for all the dosages of bio-enzyme stabilized soil samples are shown in the figure 4.

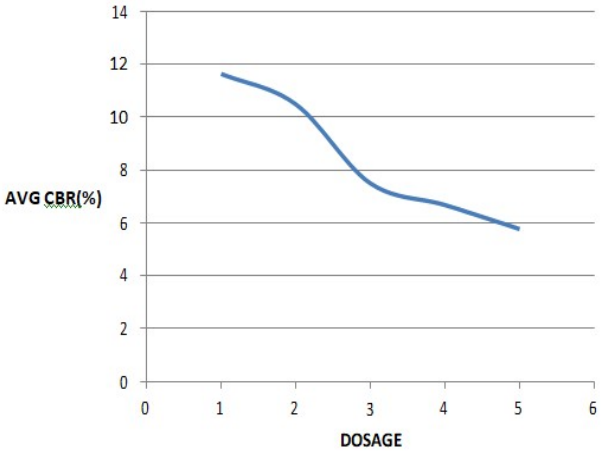

Fig. 4: Graph showing load vs. penetration curve for original soil sample (without Terrazyme

The maximum value of CBR obtained was 15.32 % for first dosage at 28 days of curing and minimum was 4.90 for dosage 5 at 7 days curing. Here the values were increases up to 5 to 6 times maximum and 2 times minimum. The unsoaked CBR was 21.67 % maximum which was approximately 7 times

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