# Soil Stabilization of BC SOIL using Bio Enzymes and Ferric Chloride

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***Abstract* — We know that the black cotton soil having less strength when it comes to the constructions of highway roads and buildings because of its swelling and shrinkage properties, so to overcome this problem in this study we are going to stabilise the black cotton soil by using bio-enzymes like zycobond, terrasil and with chemical ferric chloride. By adding the above bio-enzymes to the soil various percentages to each soil sample, the stability has been found out. The tests such as Light compaction, Heavy compaction, Liquid limit, California Bearing Ratio (CBR) has done and these results are compared to the normal soil strength. The Bio enzymes were added in 0.1% & 0.2% and ferric chloride as 0.1%. The improvement in CBR value has observed from 2.43 % to 7.29 % after stabilization with additives.**

***Keywords:- Soil stabilization, terrasil, zycobond, ferrichloride, California Bearing Ratio .***

## I. INTRODUCTION

The term Soil is a composed of minerals, organic matters and solid particles produced by disintegration of rocks. Study of soil properties has become very importance since whatever civil needs are there like roads, buildings, bridges, dams and any other infrastructure are ultimately going to transfer the loads coming on them on to the foundation soil itself. So, one must be well conversant with the properties of soil on which the structure is to implement so that engineering aspects are achieved.

As they are very fertile in nature, they are very helpful in cultivation. They are resistant to wind and water as they have an iron-rich granular structure. Black soil is high moisture retentive, so it can help in rainfed agriculture. The crack formed by black soil can be used as a passageway for rainwater. It has a high bearing capacity in a dry state.

Soil has a one bad property like shrinkage i.e., when it is in dry state, it possesses high load bearing capacity but when this BC soil comes in contact with moisture and becomes saturated, it loses its capacity of load bearing completely. Ultimately resulting in heavy depressions and settlement. In case of roads the surface and subsurface water has got tendency of easy access into subgrade soil layer through the pores, resulting in absorption of water making soil as unstable.

All the black cotton soils are not expansive soil, and also all the expansive soils are not having black colour. This BC soil possess high strength in summer and low strength in winter. Swelling and shrinkage in expansive soil causes deferential settlement resulting in severe damage to the foundation, building, roads, retaining structures and canal linings.

To prevent the structures from such damages, stabilization of soil is required with stabilizing materials like terrasil, zycobond, lime, cement, fly ash etc. The engineering properties of black cotton soil can significantly be improved with these stabilizing agents.

The aim of this study is to find the effects of bio enzymes on compression strength of soil and to improvement of bearing capacity of black cotton soil on addition of bio enzymes and chemicals. To determine the suitable combination (in %) of chemical as soil stabilizer. To minimise the cost of construction of the pavement from black cotton soil by soil stabilization technique with the help of soil stabilizers.

## II. MATERIALS AND METHODOLOGY

### *1. Materials*

The materials used in our work are Black cotton soil, Zycobond, terrasil and ferric chloride. Further details of these materials are as follows.

### 2. *Black cotton soil*

The BC soil used in present work is collected from Devarabelakere village near Davangere, Karnataka.

BC soil is a highly clayed soil and the black color in Black cotton soil is due to the presence of chemical titanium oxide. The Black cotton soil has a high percentage of clay, which is predominantly having montmorillonite in structure. Expansive soils are the soil which expands when the moisture content of the soils is increased. The clay mineral montmorillonite is mainly responsible for expansive characteristics of the soil.

Fig. 1: Black cotton soil

3. *Zycobond*

Zycobond is a co-polymer acrylic and nanotechnological additive of the latest generation. Its use is recommended in soil stabilization, for sealing the surface layer as a rolling and dust treatment. It is an additive for soil stabilization. It is soluble in water, stable to heat and ultraviolet radiation. ZycoBond is designed to be spray applied via simple dilution in water, and functions to simultaneously capture dust and waterproof the sprayed surface.


Fig. 2: Zycobond

*4. Terrasil*

Terrasil is a soil modifying additive composed of 100% organ silanes, soluble in water, stable to heat and ultraviolet radiations. Its main action, therefore, consists in water proofing of soils and sub soils. It has silanol groups, which react with the silicates present in the soil, transforming its surface and giving them permanent hydrophobic properties. In this way the soil will repel the water molecules, water proofing, it and avoiding the problems derived from its presence.


Fig. 3: Terrasil

5. *Ferric Chloride*

Ferric chloride is an orange to brown black solid. It is completely soluble in water. Ferric chloride is noncombustible. Ferric chloride is corrosive to aluminum and most metals when it is wet. Pick up and remove spilled soil before adding water. Form earlier studies it was found that $Fecl_3$ was quite effective in minimizing swelling of expansive soils. So Ferric chloride was adopted for study at optimum content of 1% to volume of soil.

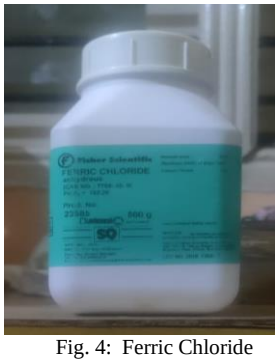

Fig. 4: Ferric Chloride

*A. Methodology*

Test on pure black cotton soil sample were carried out. Samples were prepared with an addition of Zycobond (ZB), Terrasil (TR) and Ferric chloride ($FeCl_3$) in various proportion and sufficient time was given for stabilization and various tests like liquid limit test, Proctor's test and CBR test were Carried out.

Table 1: Composition Of Samples

| Samples | Composition |
|---|---|
| BC1 | Only B.C soil |
| BC2 | B.C soil+ 0.2% ZB+ 0.2% TR+ 0.1% $FeCl_3$ |
| BC3 | B.C soil+ 0.3% ZB+ 0.1% TR+ 0.1% $FeCl_3$ |
| BC4 | B.C soil+ 0.1% ZB+ 0.3% TR+ 0.1% $FeCl_3$ |

- *Liquid Limit (LL):* The liquid limit test (Casagrande's Method) was conducted according to IS:2720-Part 5 (1985) on stabilized and unstabilized soil sample.
- *Maximum Dry Density & O.M.C:* The light and heavy compaction tests were conducted as per IS: 2720-Part 7 (1980) and IS:2720-Part 8 (1980) respectively on stabilized and unstabilized soil sample.
- *California Bearing Ratio:* This test was conducted according to IS: 2720-Part 16 (1987) on stabilized and unstabilized soil sample.

## III. RESULTS AND DISCUSSION

The effect of adding bio enzymes like zycobond and terrasil and chemical like ferric chloride in various portions on properties of black cotton soil are given below.

Table 2. Characteristics of BC soil

| Parameter | Value |
|---|---|
| Specific gravity | 2.38 |
| Liquid Limit % | 60 |
| Plastic Limit % | 35.4 |
| Plasticity Index % | 24.6 |
| MDD | 1.39 g/cc |
| CBR Unsoaked % | 2.43 |
| CBR Soaked % ( 4 days) | 2.15 |

*A. Effect on Liquid Limit*

It was observed that by addition of bio enzymes and chemical, there is increase in liquid limit of black cotton soil and it has gone up to 46.52% for sample BC2 (B.C soil+ 0.2% ZB+ 0.2% TR+ 0.1% $FeCl_3$) i.e., an increment of 10.05% compared to unstabilized soil sample.

*B. Effect on Max. Dry Density (MDD) and Optimum Moisture Content (OMC)*

It has been observed that by adding different dosage of bio enzymes and chemical, there is increase in MDD for

sample BC2 (B.C soil+ 0.2% ZB+ 0.2% TR+ 0.1% $FeCl_3$) from 1.39 g/cc to 1.45 g/cc for light and for the same combination of additives there is a increase in MDD from 1.4 g/cc to 1.48 g/cc in heavy compaction respectively.

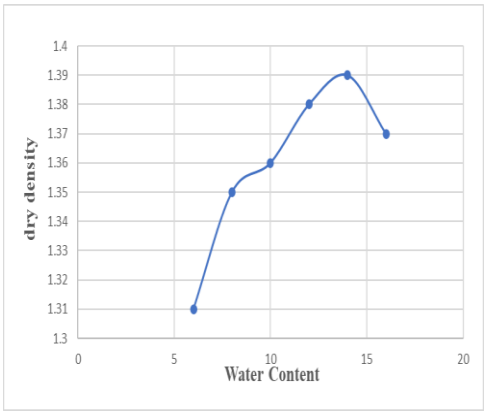


Fig. 5: Light compaction test (unstabilized soil)

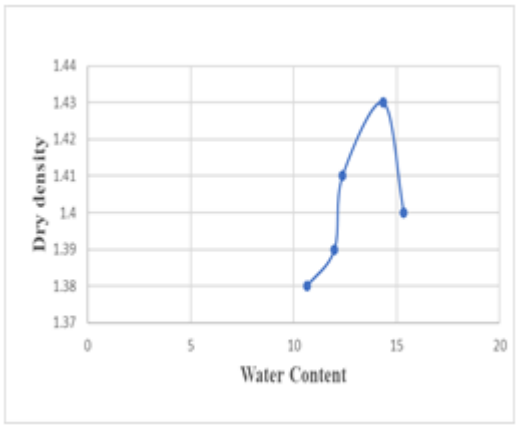


Fig. 6: Light compaction test (stabilized soil)

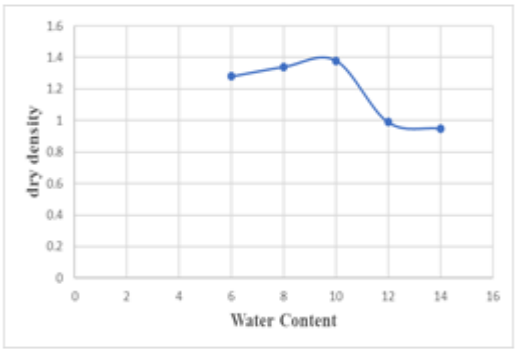


Fig 7. Heavy compaction test (unstabilized soil)

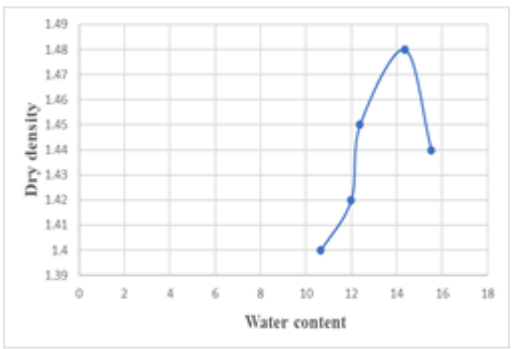


Fig 8. Heavy compaction test (stabilized soil)

*C. Effect on California Bearing Test*

It has been observed that by adding different dosage of bio enzymes and chemical, there is increase in CBR value compared to unstabilized soil. Figure 9 and Figure 10 shows the variation of CBR value for unsoaked and soaked condition respectively.

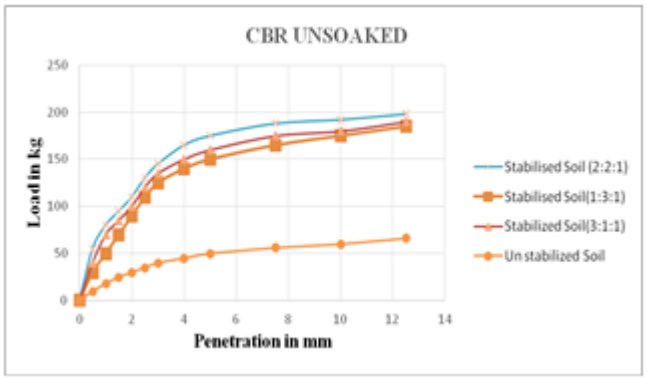


Fig 9. Variation of CBR Value for unsoaked condition

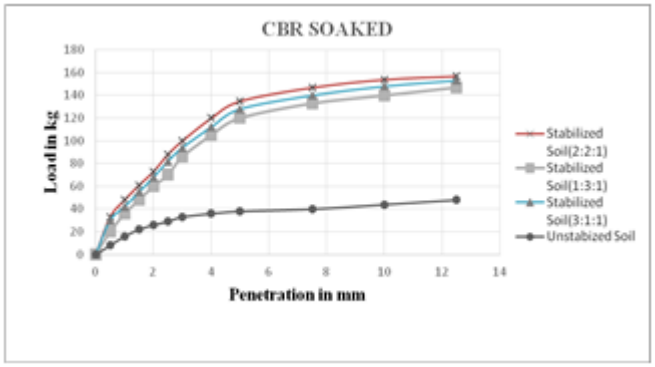


Fig 10. Variation of CBR Value for soaked condition

As it can be seen in the Fig. 5 and 6, the addition of Zycobond and Terrasil to the clayey soil, indicated improvement in the density of soil sample by light compaction test. Also, it can be seen in the Fig. 7 and 8, the addition of Zycobond and Terrasil to the clayey soil, indicated improvement in the density of soil sample from heavy compaction test.

The addition of Zycobond and Terrasil to the clayey soil, there are few combinations of chemicals to find out CBR. It can be seen in the Fig. 9, indicated improvement in the unsoaked CBR value in the range of 2.4% to 7.29 % for a dosage of 0.2% Terrasil, 0.2% Zycobond and 0.1% ferric chloride.

Fig. 10 indicated improvement in the soaked CBR value upto 5.47 % for a dosage of 0.2% Terrasil, 0.2% Zycobond and 0.1% ferric chloride.

The other combinations such 0.1% terrazil and 0.3% zycobond and vice versa also with 0.1% ferric chloride in both cases have resulted in lesser CBR value compared 0.2%+0.2%+0.1% combination.

## IV. CONCLUSIONS

Based the results and observations presented in the previous section, the following conclusions are drawn.

1. For the clay used in this study there was a double increase in the CBR value for unsoaked condition when it is stabilized with Terrasil, Zycobond and ferric chloride..

2. For the clay used in the present study, there was a drop in the CBR value when it was soaked for four days.
3. At the end it is notified that 0.2% ZB+0.2% TZ+0.1% FC combination giving significant improvement in both CBR values.

## V. SCOPE OF FURTHER STUDY

In this present work, the scope for future study is identified based on the following criteria:

1. The outcome of the present laboratory results requires extra studies to know the particle level of chemical reaction.
2. Similar studies may be taken up on different days of soaking period to study the strength gain.
3. In addition to the CBR characteristics, the effect of Zycobond, Terrasil and ferric chloride on other index and engineering properties such as Plasticity characteristics, Shear strength etc., may be investigated.

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