Indian J.Sci.Res. 17(2): 86-92, 2018 ISSN: 0976-2876 (Print)
ISSN: 2250-0138(Online)

A STUDY ON THE EFFECT OF STABILIZERS (Zycobond & Terrasil) ON STRENGTH OF SUBGRADE ON BC SOIL

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Abstract- A considerably high increase in infrastructure development has been witnessed in India since last two decades due to which the construction of pavements is taking place at a fast rate. In this process, the pavements need to be laid on soft and unfavourable grounds for most of the times. California Bearing Ratio (CBR) value of such type of subgrade soils is very low due to which the thickness of pavement layers increases. This in turn requires large quantities of natural materials leading to depletion of valuable natural resources. Conversion of locally available difficult soil into suitable construction material would be an economical solution. So, the option is to modify the properties of the existing soil so that it meets the design requirements, which is also called soil stabilisation. Cementing method of soil stabilization is an established procedure of improvement of ground used as sub-grade for pavements. In view of this, apart from the conventional cement, several commercial stabilizers have emerged in the last few years. It is therefore necessary to evaluate the effectiveness of such new commercial stabilizers vis-a-vis that of traditional stabilizer, the Cement. In line with this, an attempt has been made in the present study to evaluate the effectiveness of one of the new commercial stabilizers viz., Zycobond, Terrasil manufactured by Zydex industries vis-a-vis that of traditional stabilizer, the Cement. The scope of present study is limited to study the mechanism of stabilization process in terms of the macroscopic results of CBR values. The study is confined to one type of soil and two commercial stabilizers viz., Zycobond and Terrasil of M/s Zydex make.

Key words-Soil Stabilisation,Terrasil, Zycobond, CBR value,sub-grade

I. Introduction

In India, since last two decades, tremendous increase in infrastructure development has been taking place. As part of it, the development of pavements is taking place at a rapid pace. In the process, many a times, the pavements need to be laid on soft and un-favorable grounds, As California Bearing Ratio (CBR) value of such type of subgrade soils is very low due to which the thickness of pavement layers increases. This in turn requires large quantities of natural materials leading to depletion of valuable natural resources. Hence, of thickness of pavement layers by enhancing the CBR value of subgrade amounts to sustainable development, which is much desirable in a country like ours. At times, construction on such grounds may lead to distresses arisen from low shear strength, substantial total and differential settlement, excessive seepage and liquefaction. Conversion of locally available difficult soil into suitable construction material would be an economical solution.

For many decades, Engineers and Researchers have attempted to solve problems posed by various types of soft grounds. Due to various reasons and there may be need to improve their strength and durability.When poor quality soil is encountered at construction site, the structure can be designed accordingly or the unsatisfactory soil can be replaced with a suitable soil borrowed from nearby area. Another option is to modify the properties of the existing soil so that it meets the design requirements. This last alternative has led to the development of soil stabilization techniques. Soil stabilization methods using locally available cheaper materials have considerable scope in reducing the initial construction cost of the pavements.

But the various developmental activities necessitate making use of these lands, which are not having the desirable properties as an engineering material. The most frequent use of soil stabilization is in relation to the formation of sub-grades and sub-bases for road construction. Continued efforts are being made to improve the weak soil and hence its CBR values.

Over the years engineers have tried different methods to stabilize soils that are subject to fluctuations in strength and stiffness properties as a function of fluctuation in moisture content. Soil stabilization is a process of improving the engineering properties of the soil. Stabilization can be derived from thermal, electrical, mechanical or chemical means.

The first two options are rarely used. Chemical stabilization involves mixing or injecting the soil with chemically active compounds such as Portland cement, lime, fly ash, calcium or sodium chloride or with visco-elastic materials such as bitumen. These additives are considered as chemically active additives since they react with soils forming cementing compounds. Chemical stabilizers can be broadly divided into two groups viz., the traditional stabilizers such as hydrated lime, Portland cement and Fly ash and the non-traditional stabilizers

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comprised of sulfonated oils, ammonium chloride, enzymes, polymers, and potassium compounds. Among these, the most widely used chemical additives are lime, Portland cement and fly ash, blast furnace slag. Cement stabilization has been widely used to improve soft soils and grounds. Many researches have focused on study of the properties of the cement stabilized soil. The main purpose of this research is to improve the CBR characters of the soft clayey soil.

Main objective of this experimental study is to investigate the effect of Zycobond and Terrasil on geotechnical properties of black cotton soil.

II. Literature Review

Aparna Roy (2014) studied the high plasticity soft soil stabilized with different percentages of Rice Husk Ash and a small amount of Cement. Observations are made for the changes in the properties of the soil such as MDD, OMC, CBR and UCS. The results obtained show that the increase in RHA content increases the OMC but decreases the MDD. Also, the CBR value and UCS of soil are considerably improved with the RHA content. From the observation of maximum improvement in strength, 10% RHA content with 6% cement is recommended as optimum amount for practical purposes by observing the tremendous improvement of CBR Value of soil.

Norazlan Khalid et al. (2014) studied the effectiveness of using mixtures of lime with palm oil fly ash (Lime-POFA) in soft soil stabilization was investigated by mean of laboratory testing to evaluate the California Bearing Ratio (CBR) value. The Palm Oil Fly Ash (POFA) additives used is a finely waste product material from the process of burning palm oil fibre. The POFA used is classified as Class-F fly ash accordingly to ASTM C618 and described as siliceous and aluminous materials with possess little or no cementitious value. The optimum of 6% hydrated lime used their study as an active additive to the various % mixtures of POFA for the pozzolanic reaction. The result shown that the mixing of 6% Lime with 3% POFA was giving the higher CBR value for soaked and unsoaked condition. It shows the POFA can be used as additives to stabilized soft soil subgrade.

LEKHA B.M, et al. (2013) studied the behaviour of Black Cotton (BC) soil with and without chemical stabilizer. Terrasil was used as stabilizer and it was used for different dosages and cured for 7, 14 and 28 days . Due to the chemical reaction, the soil mass densifies by minimizing the voids between particles and it makes the soil surface impervious. The chemical compositions and microstructures of soils were analyzed using X Ray Diffraction (XRD) and Scanning Electron Microscope (SEM) respectively.

Keerthi.Y, et al. (2013) studied the stabilization of clayey soil using cement kiln waste and established that the chemical compounds found in soil; quartz, feldspar, dolomite, calcite, montmorillonite, kaolinite etc. react with the chemical constituents found in different identified chemical stabilizers .Soil containing different properties in various percentages is mixed with CKD (Cement Kiln Dust) in different proportions and parameters like dry density and moisture content are found out. After examining the values obtained ideal values are obtained at 50% proportional mix of CKD in total percentage.

Gundaliya.P.J, Ozaa J.B (2013) studied BC Soil tested using three different stabilizing agents - 1.Cement waste dust collected from the cement plant 2. Cement Dust + Lime Powder 3. Lime Powder. The cement waste dust was found best agent as a stabilizer to improve the Atterberg's Limit and hence Plasticity Index of BC Soil as well as the compressive strength of the same. Laboratory tests were performed with different percentages of three stages, each of them ranging from 1% to 9%. The behaviour of BC Soil of Rajkot region was improved with stage no. 1, the percentage of Cement dust 7% of Cement dust in BC Soil is looking to be the appropriate mixing. Also in second stage, improvement is shown at 8% of combination of cement dust and Lime powder. Third stage was observed a best suited result at 9% of Lime powder in BC Soil. They concluded after obtaining results in laboratory under standard conditions to use the Cement dust as a stabilizing agent for the purpose to improve Plasticity Index of BC Soil compare to other two combinations.

Degirmenci et al. (2007) investigated phosphogypsum with cement and fly ash for soil stabilization. Atterberg limits, standard Proctor compaction and unconfined compressive strength tests were carried out on cement, fly ash and phosphogypsum stabilized soil samples. Treatment with cement, fly ash and phosphogypsum generally reduces the plasticity index with increase in MDD with cement and phosphogypsum contents, but decreased as fly ash content increased. The OMC decreased and UCS increased with addition of cement, fly ash and phosphogypsum.

Amu et al. (2005) studied cement and fly ash mixture for stabilization of expansive clayey Soil. Three different classes of sample (i) 12% cement, (ii) 9% cement + 3% fly ash and (iii) natural clay soil sample were tested for maximum dry densities (MDD), optimum moisture contents (OMC), California bearing ratio (CBR), unconfined compressive strength (UCS) and the Undrained Triaxial tests. The results showed that the soil sample stabilized with a mixture of 9% cement + 3% fly ash is better with respect to MDD, OMC, CBR, and shearing resistance compared to samples stabilized with 12% cement, indicating the importance of fly ash in improving the stabilizing potential of cement on expansive soil.

III. Methodology

The methodology adopted to achieve the required objectives is presented below. In the present work the methodology adopted is as follows:

- Characterization of materials
- Scheme of experiments
- Experimental procedure

A. Characterization of materials

The materials used in the present work are clayey soil, zycobond and terrasil.Characterization of these materials is as given in the following sections.

Characteristics of Clayey Soil

Subgrade soil, clayey soil is used in the present work was collected from Kothapally village near Bheemadevarapally mandal, Karimnagar district, Telangana. The index and engineering properties of the soil used in this work are presented as in Table 1. The particle size distribution curve is shown in Fig.1 and compaction curve shown in Fig.2

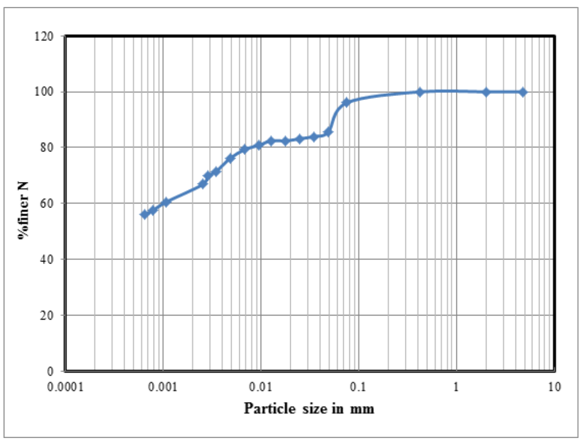

Fig.1.Particle size distribution curve

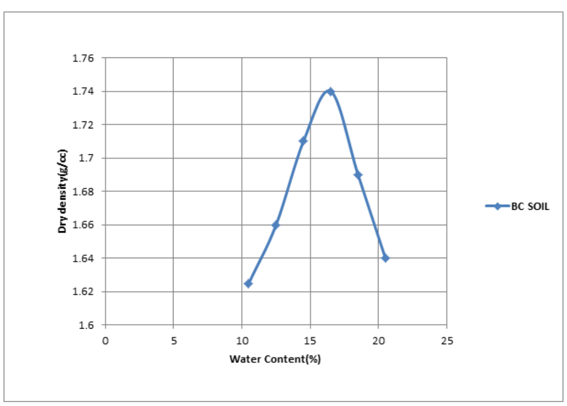

Fig.2.Compaction Curve

Table I. Characteristics of soil

Parameter	Value
Specific gravity	2.58
Differential Free Swell %	90
Liquid Limit %	60
Plastic Limit %	35.4
Plasticity Index %	24.6
Gravel Size Particles %	0%
Sand Size Particles %	33%
Silt Size Particles %	42%
Clay Size Particles %	29%
MDD (ISHCT)	1.74g/cc
OMC (%)	16.5%
Classification as per IS:1498-1970	CH
UCC kg/cm2	1.82
CBR Unsoaked %	2.7
CBR Soaked 4days %	2.18

Characteristics of Zycobond (ZB)

Zycobond is a sub-micron acrylic copolymer emulsion with long life of above 10 years for bonding soil particles. It imparts water proofing and resists water ingress through the unpaved areas like shoulders and slopes. Characteristics of the chemical stabilizer used in this work are shown in Table 2. It is manufactured by ZYDEX INDUSTRIES.A photograph of it is shown in Fig.3.

Fig.3.Zycobond

Table II.Properties of Zycobond

Parameter	Value
Colour	Milky White
Odour	No
Flash point	above 100□C
Explosion hazard	No
Ignition temperature	above 200□C
Solubility in water	Dispersible
pH value	5-6

Characteristics of Terrasil (TS)

Terrasil is nanotechnology based 100% Organosilane, Water soluble, Ultraviolet and Heat stable, Reactive soil modifier to waterproof soil subgrade. It is available in concentrated liquid form and is to be mixed with water in specified proportion before mixing with the soil.

Characteristics of the chemical stabilizer Terrasil used in this work is shown in Table.3. It is manufactured by ZYDEX INDUSTRIES.A photograph of it is shown in Fig.4.

Fig.4.Terrasil

Table III.Technical specifications of Terrasil

Parameter	Value
Appearance	Pale yellow liquid
Solid content	68+2%
Viscosity at 25□C	20-100 cps
Specific gravity	1.01
Solubility	Forms water clear solution
Flash Point	Flammable 12□C
Dosage	1% per m3

Scheme of Experiments

The detailed scheme of experiments, formulated to meet the objectives stated in the Chapter-1 is presented in this section. In the first module it is intended to study the Compaction Characteristics of soil treated by varying % dosage of Zycobond and Terrasil.In The second module aim at understanding the CBR Characteristics of soft clay treated with commercial stabilizers like Zycobond and Terrasil in unsoaked and soaked for 4days and 28days conditions. Scheme of Experiments for finding CBR Characteristics is shown in Table 4.

Table IV.Scheme of experiements for finding CBR value

Sample	Addition (kg)	Condition	No. Of tests
Only soil		Unsoaked and soaked	2
Soil +ZB+TS	0.6	Unsoaked	3
	0.75		
	1		
Soil +ZB+TS	0.6	Soaked for 7days	3
	0.75		
	1		
Soil +ZB+TS	0.6	Soaked for 14days	3
	0.75		
	1		
Soil +ZB+TS	0.6	Soaked for 28days	3
	0.75		
	1		

Experimental procedure

The test specimen is prepared as per IS: 2720 (Part16)-1987, with some modifications as per the requirement of the each specimen. The moulding dry density is calculated for each specimen.

IV. Results and Discussions

The necessary tests were carried out in this project as per the scheme of experiments presented above. The results and the observations are presented in this section systematically, as given below, pertaining to

- Un-stabilised Clayey Soil
- Clayey Soil Stabilized with Zycobond and Terrasil

The moisture-density curve of the un-stabilised clay from IS HCT was earlier presented in Fig. 2. The CBR test result of the un-stabilised clayey soil are shown in Fig. 5 and Fig.6. The test results are summarised in Table 5.

From fig.5 and fig.6,The CBR value has decreased from 2.7 % to 2.18 %, when it was soaked for four days amounting to 23.83% decrease. This significant decrease may be attributed to the plasticity characteristics of the clayey soil. The large value of PI of 35.4, as shown in Table 1 earlier, emphasizes the high plasticity of clay and hence the steep drop in CBR value.

The observations of CBR test pertaining to the clayey soil treated with 0.6kg, 0.75kg and 1kg Terrasil and Zycobond are presented in Fig. 7. Based on the analysis of results presented in Fig. 7 and Table 6, the following observations can be made:

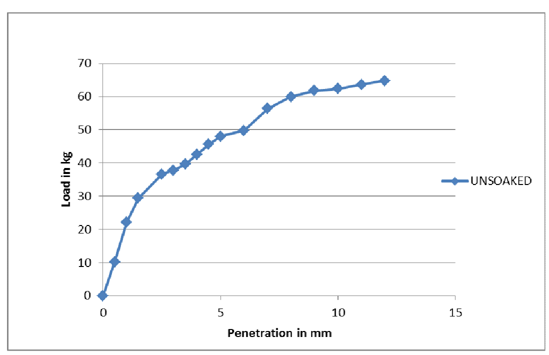

Fig.5. Load Vs penetration curve for unstabilised clay (unsoaked)

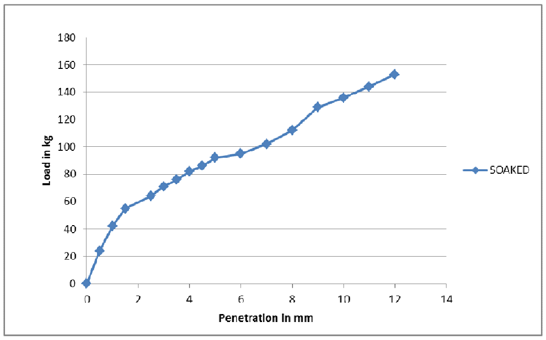

Fig.6. Load Vs penetration curve for unstabilised clay (soaked)

Table V.Summary of Test results pertaining to unstabilised soil

Test Condition	CBR Test Results	
	Unsoaked	Soaked 4 days
Unstabilised clayey soil	2.7	2.18

Table VI. Summary of Test results pertaining to Clay stabilised with TS and ZB

Terasil& Zycobond	CBR Test Results			
	Un soaked	Soaked 7 days	Soaked 14 days	Soaked 28 days
0.6 kg	6.31	3.2	3.4	3.72
0.75 kg	6.13	2.31	2.57	2.83
1 kg	5.51	1.42	1.68	1.94

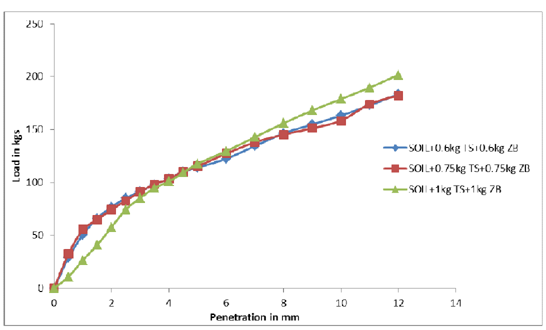

Fig.7. Load vs Penetration plots pertaining to clay stabilised with TS and ZB in Unsoaked condition

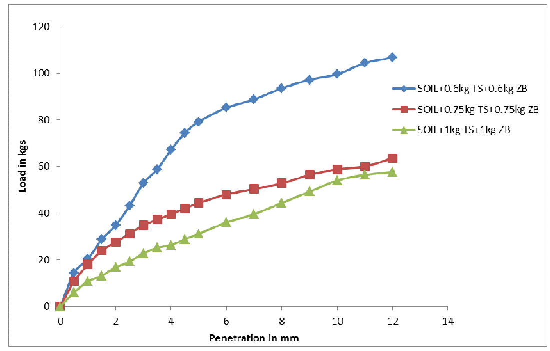

Fig.8. Load vs Penetration plots pertaining to clay stabilized with TS and ZB in 7 days soaked condition

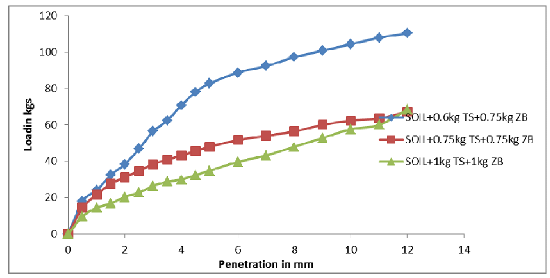

Fig.9. Load vs Penetration plots pertaining to clay stabilised with TS and ZB in 14 days soaked condition

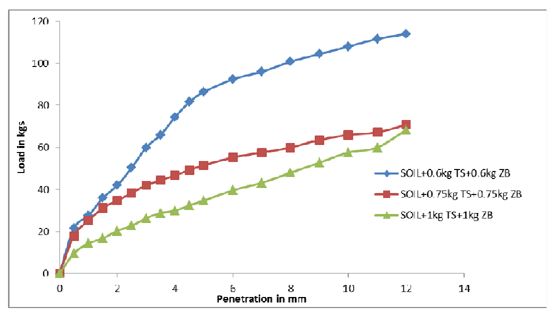

Fig.10. Load vs Penetration plots pertaining to clay stabilised with TS and ZB in 28 days soaked condition

As it can be seen in the Fig. 7, the addition of Zycobond and Terrasil to the clayey soil, indicated improvement in the un-soaked CBR value in the range of 2.7 % to 6.31 %. The zycobond being the chemical binder applied in liquid form, its effect may have commenced even during the preparation of the CBR test specimen and hence may have resulted an increase.

As it can be seen in the Fig. 8, the addition of Zycobond and Terrasil to the clayey soil, indicated improvement in the soaked CBR value in the range of 2.17 % to 3.2 % for a dosage of 0.6kg Terrasil and Zycobond.And it is observed that as the dosage increases the CBR value decreases from 2.17% to 1.42%.

As it can be seen in the Fig. 9, the addition of Zycobond and Terrasil to the clayey soil, indicated improvement in the soaked CBR value in the range of 2.17

% to 3.4 % for a dosage of 0.6kg Terrasil and Zycobond.As the curing period increases the ability to react the chemical with soil increases and it is more for 0.6kg chemical and it is gradually decreasing as the chemical dosage increases.

As it can be seen in the Fig. 9, the addition of Zycobond and Terrasil to the clayey soil, indicated improvement in the soaked CBR value in the range of 2.17 % to 3.72 % for a dosage of 0.6kg Terrasil and Zycobond.As the curing period increases the ability to react the chemical with soil increases and it is more for 0.6kg chemical and it is gradually decreasing as the chemical dosage increases.

V. Conclusions

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

- For the clay used in this study there was a increase of 57.21% in the CBR value for unsoaked condition when it is stabilized with Terrasil and Zycobond.
- For the clay used in the present study, there was a drop of 19.62 % in the CBR value when it was soaked for four days.
- All other parameters remaining same, higher the soaking period (up to 28 days observed in this study), higher was the improvement in CBR value.
- All other parameters remaining same with the increase of chemical dosage the value of CBR decreases.
- At the end it is notified that 0.6kg Terrasil and Zycobond is giving significant improvement in both CBR values.

  The level of improvement is very significant. In view of this, the practicing Engineers may consider stabilisation of soft clayey in-situ ground by Terrasil and Zycobond stabilisation, to economise the pavement layers. Interestingly, the commercial stabilisers viz., Zycobond and Terrasil, found to be more fruitful.This study is likely to provide valuable inputs to the practising Engineers. The conclusions based on the analysis of experimental results performed in the present study are presented in this chapter. At the end, the scope for future study is stated in brief.

VI. Future Scope

On the basis of present work done, the scope for future study is identified on the following aspects:

- The outcome of the present laboratory results requires microscopic studies to know the particle level chemical reaction.
- Similar studies may be taken up on different soils like non-cohesive soils and other cohesive soils.
- In addition to the CBR characteristics, the effect of Zycobond and Terrasil on other index and engineering properties such as Plasticity characteristics, Shear strength etc., may be investigated.

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