BEHAVIOUR OF EXTORTIONATE SOIL WHEN REACTED WITH CEMENT, LIME AND POP

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ABSTRACT

Soil can be defined as the upper layer of the earth consisting of air, water and solid particles is generally produced by disintegration of rocks. In the third world countries, the need for locally manufactured construction material is increasing due to greater demands for new roads and housing units created by a growing population. Over the years, the availability of conventional material has not been sufficient to meet the demand of growing population. However, development of a large network of roads by traditional means and techniques require heavy financial investments. The values of UCS for both BSL and WAS fell short of the requirement based on Road Note 31 (TRRI,1977)requirementforeconomicrangeofOPCstabilization.However,theUCS value of the BSH compaction could be acceptable for base courses of pavements. The28dayscuringperiodUCSproduced a peak value of 2616kN/m^2 at 30% pond ash & 3% alccofine for BSH compaction, showing that the soil treated with this blend can be used (at BSH compaction) as base course of pavement material.

Keywords; P.O.P, Cement, C.B.R., Lime, OMC, Maximum Dry Density, Stagilization.

I.INTRODUCTION

Soft soils exhibit major volume changes due to alternate in the moisture content. This causes main harm to property built on it. These soils include minerals such as montmorillonite that are succesful of absorbing water. When they soak up water their extent increases. Although mechanical compaction, dewatering and earth reinforcement have been found to improve the strength of the soils, other techniques like stabilization the usage of admixtures are more advantageous. The one of a kind admixtures available are lime, cement, fly ash, blast furnace slag etc. At current cement stabilization in modern times is no longer preferable due to the fact of the increasing price of cement and environmental concerns associated to its production. Lime is also no longer suitable for a soil which includes sulphates. Presence of sulfates can increase the swelling conduct of soil due to the formation of swelling minerals such as ettringite and thaumasite.

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II. LITERATURE REVIEW

Priyanka M Shaka et al studied on Laboratory investigation on Black cotton soils and Red soil stabilized using Enzyme. The most important aspect in any project is its durability and economic criteria. Recently many bio enzymes have come into existence and these were used in many constructions works. The areas of Bagalkot are covered with Black cotton soil and few areas with Red soil which have less bearing capacity. The present paper describes a study carried out for improving of geotechnical properties of soils. The collected soil samples were treated with the commercially available Enzyme and were cured for 7, 14 and 21days. The results of Consistency limits, Compaction test, Free swell index (FSI), Unconfined Compressive Strength (UCS and California Bearing Ratio (CBR) of untreated soils are presented in this paper. The engineering properties obtained for different mix proportions of soil and curing period were studied. The Free swell index (FSI) and the soaked CBR tests were conducted for the stabilized soil at different curing period.

Prof. Guruprasad Jadhav et al studied on experimental investigation of bio-enzyme stabilized expansive soil. In this study a laboratory experiments are conducted to evaluate the effects of Bio-enzymes (TerraZyme) with different dosages and curing time on the Atterberg's limit, compaction, unconfined compression (UCS) and durability for black cotton soil.

Faisal Ali et.al focuses on this research is on the improvement of engineering properties of three natural residual soils and mixed with different proportions of liquid chemical. Series of laboratory test on engineering properties, such as unconfined compressive strength (UCS), consistency limits, moisture-density relationship (compaction) was undertaken to evaluate the effectiveness and performances of this chemical as soil stal Page 14 agent. The results show that addition of the liquid stabilizer can reduce plasticity and shrinkage by elim re-absorption of water molecules; It reduces optimum moisture content by ionizing and exchanging the water molecules on the surface of the clay platelets; It increases maximum dry density by neutralizing and orderly re arranging the clay platelets and increases the compressive strength by increasing the inter particles bonding.

Venkata Subramanian et.al Three different soils with four different dosages for 2 and 4 weeks of period after application of enzyme on its strength parameters were studied. It is inferred from the results that addition of bio enzyme significantly improve UCC values of selected samples. These soil-stabilizing enzymes catalyze the reactions between the clay and the organic cat-ions and accelerate the cat-ionic exchange without becoming part of the end product.

Peng et al. Conducted unconfined compression tests on three soils; fine-grained, silty loam and coarse grained textures named as Soil I, Soil II and Soil III respectively. Three soils were stabilized with quicklime and an enzyme (Perma-zyme). The samples were cured up-to 60 days in two different conditions; air dry and in sealed container. In air-dry curing the samples were allowed to dry at room temperature where as in sealed container the moisture was preserved in the samples during the curing time. The enzyme was found more effective in air-dry curing for Soil I and Soil II than quicklime where as it was not effective for Soil III in air-dry curing and for three soils in sealed curing too. In sealed containers, the quicklime was found more effective than the enzyme as the water in the specimens was not allowed to evaporate which promoted the further hydration of quicklime.

Shukla.M et al Made experiments on an expansive soil treated with an organic, non-toxic, ecofriendly bio-enzyme stabilizer in order to assess its suitability in reducing the swelling in expansive soils. The experimental results indicate that the bio enzyme stabilizer used in the present investigation is effective and the swelling of an expansive soil reduces on wet side of OMC.

M B Mgangira et al Thus the aim of this paper is to present laboratory results on the effect of enzyme based liquid chemicals as soil stabilizer. 1 soil had plasticity index of 35 and the other had PI of 7. Tests –Atterberg's limits Standard proctor and unconfined compressive strength.

III. MATERIAL USED

a) SOIL

Most of stabilization has to be undertaken in soft soils (silty, clayey peat or organic soils) in order to reap appropriate engineering properties. Fine-grained granular substances are the easiest to stabilize due to their large floor vicinity in relation to their particle diameter. A clay soil compared to others has a massive floor location due to flat and elongated particle shapes.

Table 1 Property Of Soil

PROPERTY OF SOIL	RESULT
Specific gravity of soil	2.70
I.S Classification	Silty Sand (SM)
Maximum Dry density	2.02 grams/cubic centimeters
Optimum moisture content	10.1 %

b) CEMENT

Cement is the oldest binding agent since the invention of soil stabilization technology in 1960's. It may additionally be regarded as foremost stabilizing agent or hydraulic binder because it can be used on my own to deliver about the stabilizing action required. Cement reaction is now not based on soil minerals, and the key position is its reaction with water that may also be accessible in any soil. This can be the reason why cement is used to stabilize a extensive vary of soils. Numerous kinds of cement are available in the market; these are everyday Portland cement, blast furnace cement, sulfate resistant cement and high alumina cement. Usually the choice of cement depends on type of soil to be treated and favored ultimate strength. Hydration procedure is a manner below which cement response takes place. The system begins when cement is combined with water and other components for a desired software resulting into hardening phenomena. The hardening (setting) of cement will enclose soil as glue, however it will no longer trade the shape of soil .The hydration response is gradual proceeding from the surface of the cement grains and the centre of the grains can also stay unhydrated. Cement hydration is a complex procedure with a complicated series of unknown chemical reactions. However, this manner can be affected via presence of foreign matters or impurities.

- water-cement ratio
- curing temperature
- presence of additives
- Specific surface of the mixture.

c) LIME

Lime provides an economical way of soil stabilization. Lime modification describes an increase in strength brought by cation exchange capacity rather than cementing effect brought by pozzolanic reaction. In soil modification, as clay particles flocculates, transforms natural plate like clays particles into needle like interlocking metalline structures. Clay soils turn drier and less susceptible to water content changes. Lime stabilization may refer to pozzolanic reaction in which pozzolana materials reacts with lime in presence of water to produce cementitious compounds. The effect can be brought by either quicklime, CaO or hydrated lime, Ca $(OH)_2$. Slurry lime also can be used in dry soils conditions where water may be required to achieve effective compaction. Quicklime is the most commonly used lime; the followings are the advantages of quicklime over hydrated lime.

- higher available free lime content per unit mass
- denser than hydrated lime (less storage space is required) and less dust
- Generates heat which accelerates strength gain and large reduction in moisture content according to the reaction equation below.
  $CaO + H_2O = Ca\,(OH)_2 + \text{Heat}\ (65\ \text{KJ/mol})$

Quicklime when mixed with wet soils, immediately takes up to 32% of its own weight of water from the surrounding soil to form hydrated lime; the generated heat accompanied by this reaction will further cause loss of water due to evaporation which in turn results into increased plastic limit of soil i.e. drying out and absorption.

d) FLY–ASH

Fly ash is a byproduct of coal fired electric power generation facilities; it has little cementitious properties compared to lime and cement. Most of the fly ashes belong to secondary binders; these binders cannot produce the desired effect on their own. However, in the presence of a small amount of activator, it can react chemically to form cementitious compound that contributes to improved strength of soft soil. Fly ashes are readily available, cheaper and environmental friendly. There are two main classes of fly ashes; class C and class F .Class C fly ashes are produced from burning sub bituminous coal; it has high cementing properties because of high content of free CaO. Class C from lignite has the highest CaO (above 30%) resulting in self-cementing characteristics (FM 5-410). Class F fly ashes are produced by burning anthracite and bituminous coal; it has low self-cementing properties due to limited amount of free CaO available for flocculation of clay minerals and thus require addition of activators such as lime or cement. The reduction of swell potential achieved in fly ashes treated soil relates to mechanical bonding rather than ionic exchange with clay minerals.

e) BLAST FURNACE SLAGS

These are the by-product in pig iron production. The chemical compositions are similar to that of cement. It is however, not cementitious compound by itself, but it possesses latent hydraulic properties which upon addition of lime or alkaline material the hydraulic properties can develop .Depending on cooling system, - Air-cooled slag .Hot slag after leaving the blast furnace may be slowly cooled in open air, resulting into crystallized slag which can be crushed and used as aggregate. Under certain conditions, steam produced during cooling of hot slag may give rise to expanded slag.

f) POZZOLANAS

Pozzolanas are siliceous and aluminous materials, which in itself possess little or no cementitious value, but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties (ASTM 595). Clay minerals Page 9 kaolinite, montmorillonite, mica and illite are pozzolanic in nature. Artificial pozzolanas such as ashes are products obtained by heat treatment of natural materials containing pozzolanas such as clays, shales and certain silicious rocks. Plants when burnt, silica taken from soils as nutrients remains behind in the ashes contributing to pozzolanic element. Rice husk ash and rice straw and bagasse are rich in silica and make an excellent pozzolana.

IV. GEOTECHNICAL PROPERTIES OF SOIL

The properties discussed include Atterberg's limits, the different densities, particle size distribution, permeability, and the parameters related to consolidation and shear strength. The tests required to obtain these parameters are also discussed .The tests conducted at laboratory to know the various Geotechnical properties of clayey soil is discussed in this section. The various geotechnical properties of soil are discussed in table

TABLE 2 GEOTECHNICAL PROPERTIES OF SOIL

Laboratory tests	IS code Standards	Soil sample name			
		S1	S2	S3	S4

Sp. Gravity	**IS-2720 (Part3): 1980 Sect/2**	2.63	2.75	2.84	2.81
Grain size distribution					
Sand (%)	**IS-2720 (Part4):1985**	4	6	2	60.1
Silt (%)		17	11	8	35.4
Clay (%)		74	85	91	38.3
Liquid limit (LL)	**IS-2720 (Part VII): 1972**	53.60	68.85	78.54	29.8
Plastic limit (PL)		34.85	36.87	46.84	18.98
Plastic Index (PI)		21.25	33.65	38.74	5.87
Shrinkage limit		12.43	8.47	7.32	14.58

V. CALIFORNIA BEARING RATIO TEST

Soaked CBR test was conducted by mixing the soils at soaked condition. Predetermined quantity of water is mixed with cement and lime was added corresponding to optimum moisture content by standard proctor's test for the mix, mixed thoroughly. These mixes were compacted in CBR mould to maximum proctor's density. Two identical specimens which were prepared as per IS code 2720- PART XVI, kept in air tight bags for testing 7, 14 and 21 days curing and was soaked in water for 96hours before testing of curing period, then tested for CBR. The following figure and graph of soaked CBR (%) virus soil sample represents effect of enzyme reacting on the soils at different curing period.

The Table 3 provides the details of soaked CBR test results of effect for soil samples.

Table 3: CBR values of various mixes

Soaked CBR values in %								
Dosage	**3 %**		**6 %**		**9 %**		**11 %**	
Stabilizer	**Lime**	**Cement**	**Lime**	**Cement**	**Lime**	**Cement**	**Lime**	**Cement**
CBR in % at 2.5 mm Penetration	4.28	4.54	4.78	4.89	6.58	6.87	5.32	5.87

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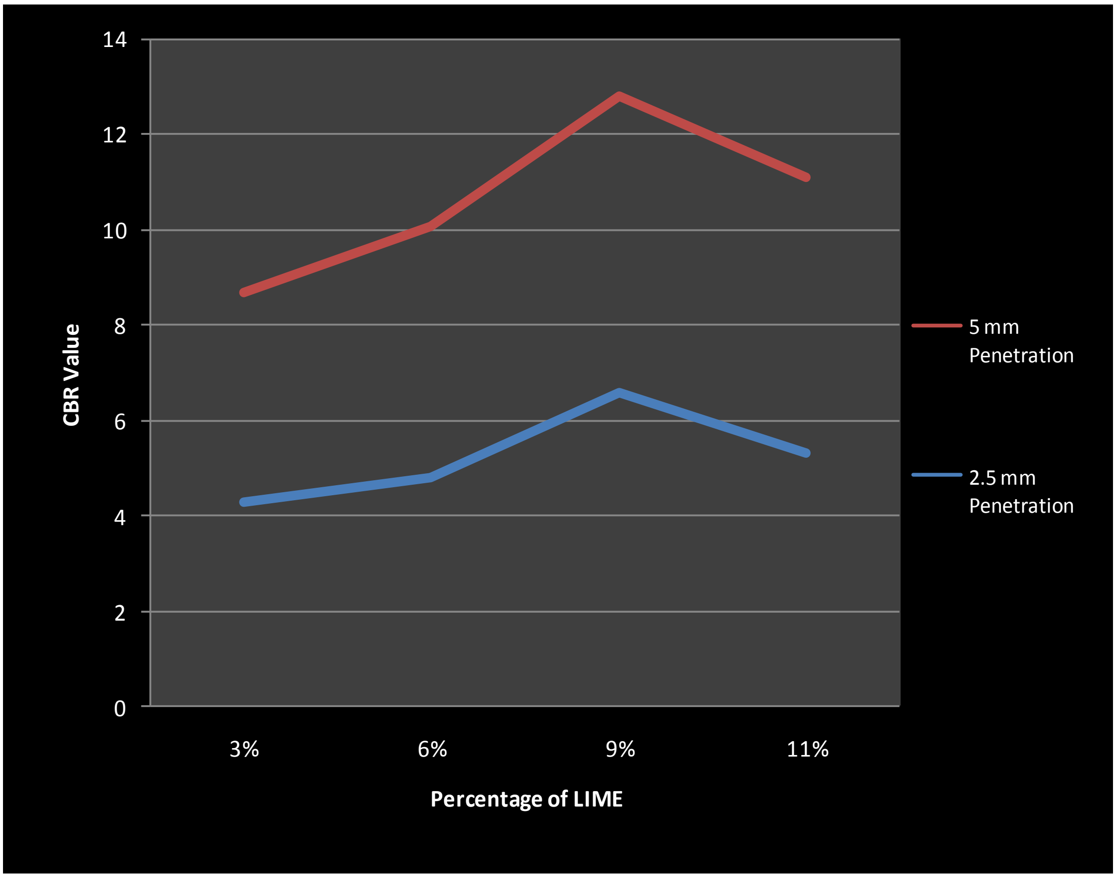
CBR in % at 5 mm Penetration	4.41	4.75	5.30	5.84	6.21	6.42	5.79	5.21

Figure 1: Effect of Lime on CBR Value



VI. UNCONFINED COMPRESSION TEST

The unconfined compressive strength (UCS) is the maximum axial compressive stress that a right-cylindrical sample of material can withstand under unconfined conditions—the confining stress is zero. It is also known as the uniaxial compressive strength of a material because the application of compressive stress is only along one axis. To observe the effect of curing time on the UCS, clayey soils with different plasticity indexes were mixed with different percentages of lime and cement and tested at 7 and 28 days of curing time. The results of unconfined compressive strength on stabilized and unstabilized soils at different curing times are presented in

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Figure 4.3, figure 4.4 and Table 4.3 Note that qu is the UCS of the samples and q0 is the unconfined compression test.

Table 3: UCS values of various mixes

UNCONFINED COMP. STRENGTH (kg/cm2)								
Dosage	**3 %**		**6 %**		**9 %**		**11 %**	
Stabilizer	**Lime**	**Cement**	**Lime**	**Cement**	**Lime**	**Cement**	**Lime**	**nent**
7 Days	1.23	1.58	1.43	1.89	1.65	1.97	1.79	03
28 Days	1.74	1.98	1.78	1.99	1.87	2.13	1.95	24

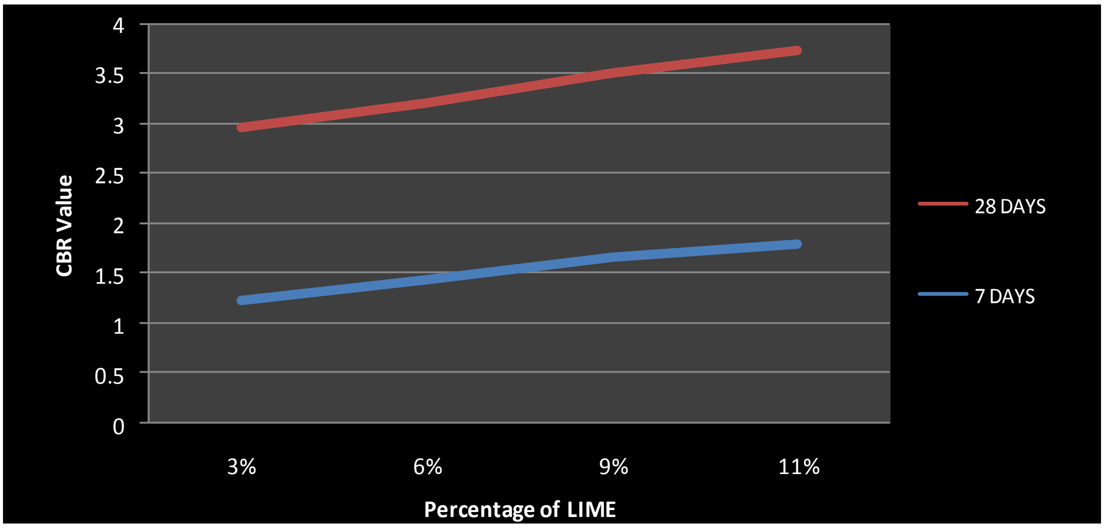

Figure 3: Effect of Lime on UCS Value

VII. STABILIZATION USING POP

DATA SHEET FOR CBR TEST:

FOR 2% POP:

Observations and calculations:

Diameter of the CBR mould, (d) = 15 cm

Radius of the CBR mould, (r) = 7.5 cm

Height of the CBR mould, (h) = 17.5 cm

Volume of the CBR mould, (V) = $\pi r^2 h$

$= 3.14 \times 7.5^2 \times 17.5$

$= 3090.93\ cm^3$

Height of the disc = 4.8 cm

Net height of the mould, (h") = 17.5 – 4.8 = 12.7 cm

Net volume = $3.14 \times 7.5^2 \times 12.7$

$= 2243\ cm^3$

Optimum moisture content = 22.9 %

Max. dry density = 1.670 g /cm^3

Mass of soil sample required = 2243 × 1.670 = 3746 g

Mass of Pop = 2% of 3746 = 75 g

Least count of proving ring = 1.154 kg

Least count of dial gauge = 0.01 mm

Result: CBR (2.5 mm) = $\frac{\text{Corrected load at 2.5 mm}}{1370} \times 100$

$= \frac{171.946}{1370} \times 100 = 12.55\%$

CBR (5.0mm) = $\frac{\text{Corrected load at 5.0 mm}}{2055} \times 100$

$= \frac{229.646}{2055} \times 100 = 11.17\%$

Design CBR value = **12.55 %**

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FOR 4% POP:

Observations and calculations:

Diameter of the CBR mould, (d) = 15 cm

Radius of the CBR mould, (r) = 7.5 cm

Height of the CBR mould, (h) = 17.5 cm

Volume of the CBR mould, (V) = $\pi r^2 h$

$= 3.14 \times 7.5^2 \times 17.5$

$= 3090.93\ cm^3$

Height of the disc = 4.8 cm

Net height of the mould, (h") = 17.5 – 4.8 = 12.7 cm

Net volume = $3.14 \times 7.5^2 \times 12.7$

$= 2243\ cm^3$

Optimum moisture content = 22.9 %

Max. dry density = 1.670 g /cm^3

Mass of soil sample required = 2243 × 1.670 = 3746 g

Mass of pop = 4% of 3746 = 150 g

Least count of proving ring = 1.154 kg

Least count of dial gauge = 0.01 mm

Result: CBR (2.5 mm) = $\frac{\text{Corrected load at 2.5 mm}}{1370} \times 100$

$= \frac{283.884}{1370} \times 100 = 20.72\%$

$$\text{CBR (5.0mm)} = \frac{\text{Corrected load at 5.0 mm}}{2055} \times 100$$

$$= \frac{461.6}{2055} \times 100 = 22.46\%$$

Design CBR value= **22.46 %**

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