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Investigation of Soil Stabilization Using Lime

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ABSTRACT *:*The Lime stabilization is one of the techniques that can be used for improving the engineering properties, particularly the strength characteristics of clays. This project aims to investigate the effect of hydrated lime on the strength of lime treated clays. In order to illustrate such effect, a series of laboratory tests were conducted like Atterberg limits, unconfined compressive strength tests were carried out on clay. It is then mixed with 8% hydrated lime. The results indicated that the addition of lime resulted in an improvement in strength properties. The unconfined compressive strength (UCC) and CBR value of stabilized clay experienced an increase with lime addition. Generally the amount of lime used to modify the cementation properties varies from 2 to 8 percent. When lime is added to clay soils, calcium ions are combined initially with clay mineral which leads to an improvement in soil properties. The increase in strength has been attributed to the formation of pozzolanic projects which surround the clay minerals. This study focuses on the strength improvement of soil treated with lime.

KEYWORDS–Soil stabilization, Lime, Optimum lime content, UCC, CBR.

I. INTRODUCTION

For any land-based structure, the foundation is very important and has to be strong to support the entire structure. In order for the foundation to be strong, the soil around it plays a very critical role. So, to work with soils, we need to have proper knowledge about their properties and factors which affect their behavior. The process of soil stabilization helps to achieve the required properties in a soil needed for the construction work. The chemical reactions between clay particles and lime can be categorised into two forms of improvement, short term reaction (modification) and long term reaction (stabilisation). In the first reaction the process of ion exchanges makes the clay minerals flocculate and agglomerate leading to a reduction in plasticity, swell and moisture content. The second reaction (pozzolanic reaction) accomplishes over a period of time creating cementing products that cause long-term strength gain. This paper aims to investigate the strength and the microstructure of lime treated clay using unconfined compressive strength test and California bearing test. For this purpose, method was used to determine the required amount of hydrated lime to be mixed with commercial lime mixtures were prepared with 5% lime and compacted at optimum moisture content.

II. MECHANICAL METHOD OF STABILIZATION

In this procedure, soils of different gradations are mixed together to obtain the desired property in the soil. This may be done at the site or at some other place from where it can be transported easily. The final mixture is then compacted by the usual methods to get the required density. There are two stages of lime stabilisation. The first stage involves ion exchange on the surfaces of clay minerals (to produce calcium clays) whilst the second stage removes silica (and some alumina) from the clay mineral lattice, The initial exchange and chemical attack produces a gel with hardens to form an interlocking structure. The clay is an integral component of the bonded mass in its degraded form, and not merely an inert filler as it is in cement stabilisation. Lime stabilisation is characterised by an extremely rapid reaction, at exposed surfaces of clay clods, which converts even heavy clays into friable soil immediately upon mixing. In addition lime stabilisation immediately transforms a clay soil which would otherwise

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soften, collapse, and disperse in water, into a firm water-resistant material. The speed of the reaction makes it particularly suited for stiffening soft soils. limestabilisation also increases the strength of all clayey soils, increases their permeability, increases their erosion resistance, and markedly increases their volume stability against swell and shrink. However, in most cases clays stabilised with lime do not develop as much stiffness as when mixed with cement. All the same, as with cement, the mode of failure of the soil is changed from plastic to brittle after lime treatment and compaction at optimum moisture content. When lime is added to a soil, it must first satisfy the affinity of the soil for lime. In other words ions are adsorbed by clay minerals and are not available for pozzolanic reactions until this affinity is satisfied. Because this lime is fixed in the soil and is not available for other reactions, the process has been referred to as lime fixation. Hence the amount of lime required to bring about lime fixation is related to the proportion of clay minerals present in a soil and is independent of carbonate content, that is, it is related to the cation exchange capacity of a soil.

A number of explanations have been proposed as mechanisms responsible for the changes which occur in the engineering properties of a soil when it is mixed with lime and water. They include cation exchange, flocculation of the clay, carbonation and pozzolanic reactions. The first tyro reactions take place rapidly and produce immediate changes in plasticity, workability and swell properties, as well as the immediate uncured strength and load deformation properties. Plasticity and swell are reduced and workability is substantially improved as a result of the low plasticity and friable character developed by the lime-soil mixture. The third reaction is undesirable because it gives rise to weak cementing agents. The fourth reaction is time dependent, in other words strength development is gradual but continues for a long period.

III. EXPERIMENTAL INVESTIGATION

3.1 Experimental investigation before adding lime

The experimental work consists of the following steps:

a) Specific gravity of soil

b) Determination of soil index properties (Atterberg Limits)

i) Liquid limit by Casagrande's apparatus

ii) Plastic limit

c) Particle size distribution by sieve analysis

d) Determination of the maximum dry density (MDD) and the corresponding optimum moisture content (OMC) of the soil by

Proctor compaction test

e) Determination of shear strength by:

i) Unconfined compression test (UCS).

ii) Determination of CBR value

S.No	Soil Properties	Values
1	Specific Gravity	2.71
2	Soil Index	
	i) Liquid limit	53%
	ii) Plastic limit	34.58%
	iii) Plasticity Index	18.42%
3	Particle size distribution	Cumulative percent of passing (%)
	Sieve size (mm)	
	4.75	87.5
	2.36	83.7
	1.18	79.75
	0.6	76.05
	0.3	69.8

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	0.15	64.05
	0.075	63.45
4	Optimum moisture content	14%
5	Unconfined compression test	0.31 Mpa
6	CBR at 2.5mm penetration	4.17%

Table-1 Properties of clay soil

3.2 Experimental investigation after adding lime
a) Variation of pH with addition of Lime:

S.No	Lime content (%)	Values
1	0	8.4
2	5	8.95
3	6	9.25
4	7	10.55
5	**8**	**10.57**
6	9	10.59

Table-2pH variation of soil with lime addition

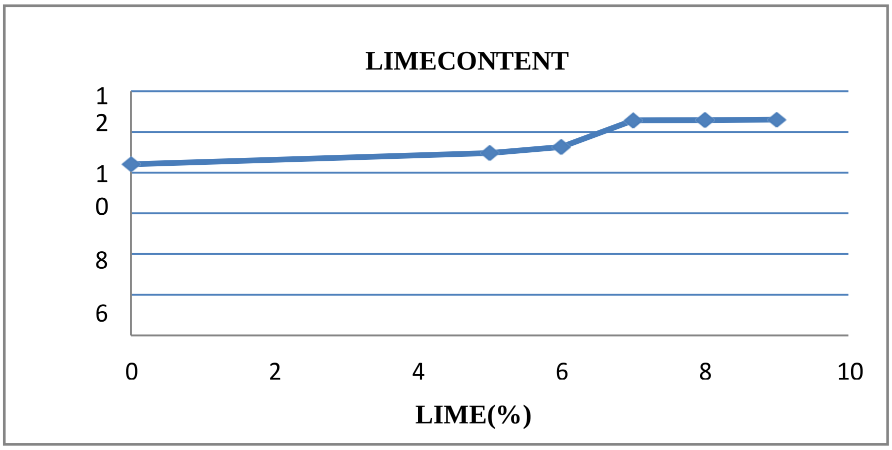

Fig-1pH variation of soil with lime addition

b) UCC Test for lime treated sample:

S.No	Deformation reading	Force in div	Load in kg	Change in length	Strain	Corrected area	Axial strain	Axial stress (N/cm^2)
1	0	0	0	0	0	0	0	0
2	50	12	18.8	0.5	0.01	11.41	0.59	1.65
3	100	17	26.6	1	0.01	11.48	1.18	2.33
4	150	22	34.5	1.5	0.02	11.54	1.76	2.99
5	200	25	39.2	2	0.02	11.61	2.35	3.38

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6	250	28	43.9	2.5	0.03	11.68	2.94	3.76
7	300	33	51.8	3	0.04	11.76	3.53	4.41
8	350	37	58	3.5	0.04	11.83	4.12	4.91
9	400	34	53.3	4	0.05	11.9	4.71	4.48

Table-3UCC Test values

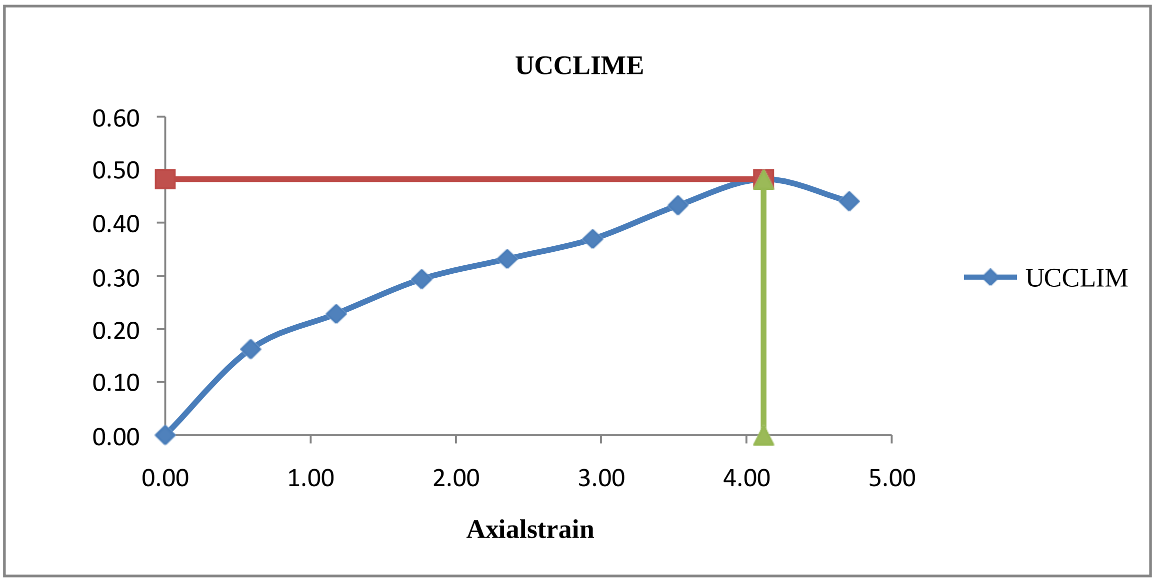

Fig-2UCC strength curve for lime treated sample

c) CBR Test for lime treated sample:

S.No	Penetration (mm)	Load (N)	Corrected Value (Kg)
1	0	0	0
2	0.5	21	37.46
3	1	33	58.87
4	1.5	41	73.14
5	2	49	87.41
6	2.5	54	96.33
7	3	57	101.68
8	4	62	110.6
9	5	66	117.74
10	6	69	123.09
11	7.5	73	130.22
12	10	75	133.79
13	12.5	78	139.14

Table-4CBR Test observations for soil sample treated with lime

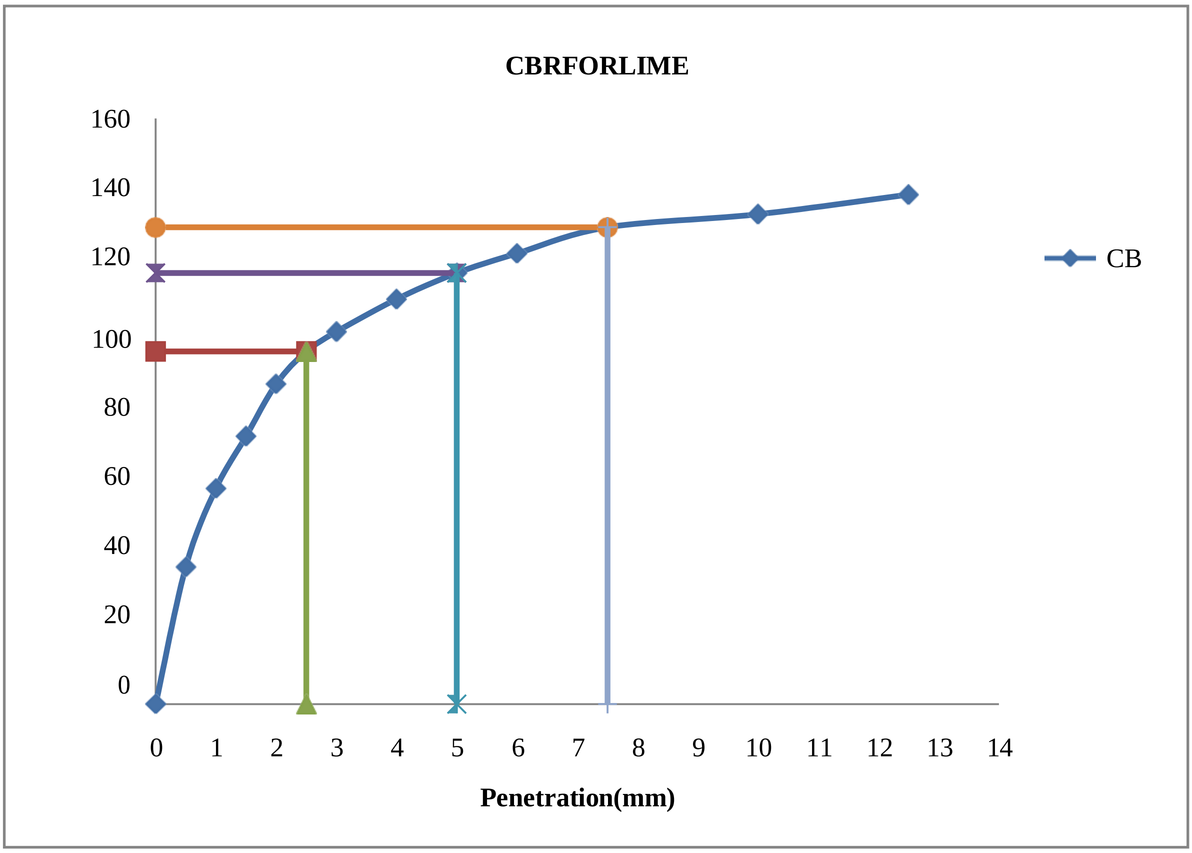

Fig-3CBR Curve for the lime mixed sample

IV. CONCLUSION

On the basis of present experimental study, the following conclusions are drawn:

1. Addition of lime to soil sample shows an increase in the strength of the soil sample which is assured using the UCC values
And CBR values.
2. Unconfined compressive strength of soil increases with the addition of hyrated lime upto 8%and then strength of the soil
decreases,therefore it reaches the saturation point.
3. The UCC value for lime treated sample at 8% is 0.48 MPa which higher than that of 0.31 MPa which shows that lime
content increases the unconfined shear strength
4. CBR value is found to increases on addition of lime in various percentage to soil.
5. CBR increases upto 7.1% on adding lime at 8%
6. Optimum lime content is found by the variation of the pH value with addition of lime.
7. When lime is added beyond 8% it reaches saturation point and it has no effect on soil
8. The percentage of lime added saturates the soil which is found by variation of pH to the different proportion of lime on the soil.
   i. From Quantitative analysis, it may be concluded that the quantity of drinking water needed = 1000 L/day.
   ii. From the Qualitative analysis, it may be concluded that the Total salts, Sulphates, Magnesium, COD were above the permissible limit as per BIS 10500 for drinking water.
   iii. The proposed layout consists of Activated Carbon Column and Reverse Osmosis Plant.

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