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Determination of Consolidation Characteristics and Compressibility of Lime Stabilized B.C Soil and Possibility of Leaching and Replacement of Ca^{++} ions

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Abstract - *Since long improvement in characteristics of expansive soil by using different materials has been a challenging job for engineers. The objective of this study was to evaluate the effect of lime in stabilization of expansive soil and aim of this research is to stabilize and improve the soil. The consolidation and compressibility characteristics of unsterilized and lime stabilized soils are determined by conducting standard odometer test. The liquid limit of unsterilized soil was 65.8% and soil samples are prepared with different proportions of lime (i.e., 6%, 8%, 10% and 12%). The liquid limit decreased to 54.8% when soil is treated with 6% lime. The liquid limit of soil decreases as the lime content increases beyond the optimum lime content the liquid limit increases and unconfined compressive strength increases with increase in lime stabilized soil and also increase in lime content beyond optimum lime content decreases the unconfined compressive strength of soil due to excess lime. By addition of lime, stabilization improved the consolidation characteristics by reducing the voids and reduction in settlement was achieved. The Na+ ions and k+ ions showed the replacement by ca++ ions when the stabilized soil and 10% lime stabilized soils were passed with various pore fluids. When excess of ca++ ions provided through pore fluids and also when they were not completely utilized in the stabilization process as the process is a long term reaction, there was leaching of ca++ ions. The reduction in ions concentration was influenced by load increases*

Key Words: **leaching, ca^{++}ions, Electrolyte solutions (Pore fluids). Lime Black Cotton soils. Sodium chloride (NaCl), 1N Potassium Chloride (KCl) and 1N Calcium chloride ($CaCl_2$)**

1. INTRODUCTION

Based on field application to meet the particular engineering requirements lime stabilization is a technique where lime behaves as a stabilizing agent that modifies “the properties of a soil chemically”.

For settlement and consolidation soft clay is always plays key role. To increased strength, reduced compressibility and shrinkage the stabilization of soft clay along with lime is required. For geotechnical engineer Clay soils offer a challenge due to their significant diversity in requisites of concerto and resources and specific their dissimilarity in resources with time and loading. The strength of the clay increases along with properties changes frequently are often a manifestation of clay’s ability to develop high pour water pressures both negative and positive. As per engineering practice whether applied statically or dynamically as a cyclic loading the pressures influence greatly the stress that clay can withstand regularly. The properties of a clay soil are mainly restricted by quantity and kind of clay soils, as resolute by clay portion and clay mineralogy correspondingly and its stress account. The clayey soil containing montmorillonite as the clay mineral are susceptible for large amount of volume changes with changes in moisture content. Also they lose considerable amount of strength when water seeps into such soils. Modification in soil properties has to be done to take up construction activity associated with such soils as per the field requirements. Various methods are adopted to modify soil characteristics, such as preloading, sand drains (vertical and horizontal), stabilization etc. Normally lime stabilization is found to be very valuable and economical method of stabilizing the soils. But when lime is additional to a clay soil, it becomes a different material (composite material) altogether and behavior of lime stabilized soil is very much different from clay soil.

The present study therefore objectives to reveal additional in sequence about the result of lime stabilization on the consolidation individuality of soil, And also to determine the effect of pore fluids on un stabilized and lime stabilized black cotton soils.

Table 1.1 General chemical properties of black soil

Description	Formula	Range
Carbonate (%)	CO_3	0.5-6.6
Silica (%)	SiO_2	48-58
Alumina (%)	Al_2O_3	13-22
Magnesium oxide (%)	MgO	1.8-5
Ferric oxide (%)	Fe_2O_3	7.5-15
Titanium oxide (%)	TiO_2	0.3-2.2
Sulphates (%)	SO_3	0.9-2
Organic matter (%)		0.4-3.6
pH		6.7-8.9

Table 1.2 Major soil groups and their properties

Group designation	Minerals included	Mean Size	Chief physical properties
Very fine sand (Si)	Quartz	>1 μm	Cohesion less, abrasive
Mica	Muscovite, Biotite	>1 μm	Cohesion less, weathers easily, resists compaction
Carbonate	Calcite, Dolomite	Any	Pulverizes readily
Sulphate	Gypsum	>1 μm	Can disrupt cement work
Illite	Illite and partially degraded Mica	≈ 1 μm	Expansive, medium plasticity, low permeability
Chlorite	Chlorite vermiculite	≈ 0.1 μm	Limited swelling, low shear resistance
Allophane	Amorphous Aluminosilicates, Attapulgite, Hydrous Alumina and Silica	Any	High void ratio, high plasticity, often irreversibly reduced by air drying
Kaolin	Kaolinite halloysite	≈ 1 μm	Non-swelling, low plasticity low cohesion
Montmorillonite	Montmorillonite, Bentonite, mixed layer expansive clays	≤ 0.01 μm	Highly expansive, very plastic, extremely low permeability

2. LITERATRAUTRE REVIEW

2.1 General

Extroverted clays have the capability to produce marvelous pressure on structures such as concrete fundamentals. These high pressures are the explanation to the disparaging power of unreserved clay in creating foundation troubles. These pressures can be on the arrange of 15,000 pounds per square foot. Growth in regions wherever difficulty soils are predictable has been a main source of unease to the engineer. To overcome this problem, different methods of ground development techniques were used among which the lime stabilization is the popular and easier one for application.

Many investigations have been carried out in this regard. Some of the studies related to lime stabilization are illustrated below.

1. "Attom et al (2000)": explained soil stabilization as the enhancement of soil engineering and physical resources such as growing its strength and sinking or removing its extension.
2. "Johnson et al (1988)": stabilization infers enhancement in together potency and robustness.
3. "Eades and Grim (1960)" : establish that there contains a chemical reaction involving lime and clean clay minerals (Kaolinite,illite and montmorillonite) with associated increase in behavior value. The amount of lime desired to efficiently pleasure a soil to expand enhance strength differs with the kind of clay mineral exists.

3. MATERIALS AND METHODS

In a geotechnical engineering practice, the soils at an agreed site are frequently less than model and may cause harm to structures. Such soils need modification/improvement in their engineering properties. There are quantities of additives which may be consumed for the change. Most frequently used additives are "Portland cement, lime, fly ash and lime-fly ash". Lime behavior in cohesive soils normally cause a reduce in "plasticity, dispersion and volume change potential and enlarge in particle size, permeability and strength".

The major part of Bidar district consists of B.C.Soil.The B.C.soil of this area was selected for studying the behavior of Unsterilized and lime stabilized soil.

3.1 Black Cotton soils.

The B.C soil, in and around Bidar District consists of high value of liquid limit which is a challenge to the Civil engineers for construction work. The "black cotton soil obtainable in the area of Bhalki area Bidar district in Karnataka state was used in this examination". The soil was composed from deep level 0.5 mts form usual ground level and the geotechnical resources of this soil were designed by functioning assorted laboratory tests. The test consequences are presented in the Table 3.1.The soil is confidential as CH on the Casagrende's plasticity chart.

Table 3.1 Index, physical and engineering properties of soil

Properties	B.C. Soil
Color when dry	Black
Specific gravity, G	2.70
Atterberg Limits;	
Liquid limit, w_L (%)	65.8
Plastic limit, w_P (%)	35.5
Plasticity index, I_P (%)	29.4
Shrinkage limit, w_S (%)	10.2
Unified classification	CH
Compaction characteristics;	
Maximum dry density, ρ_{dmax} (N/m^3)	14.8
Optimum moisture content, w_{OMC} (%)	29.4
Grain size distribution;	
Gravel and sand (%)	14.89
Silt and clay (%)	83.91
Unconfined compressive strength (N/m^2)	34.5

3.2 Lime

In this project lime used is "Calcium hydroxide (i.e. Ca $(OH)_2$)", since it is effective stabilizer of black cotton soil. Various methods have been used to determine optimum quantity of lime. "For plasticity index (PI) decrease and workability enhancement (i.e. soil alteration) adequate lime should be supplementary as those extra calculations do not consequence in a modify in the plasticity catalog. This is named as Lime Fixation proportion". For lime stabilization, small preference to use the technique recommended by Thomson connecting the use of pH testing enlarged by 28 days UCS testing institute the most favorable lime satisfied.

Here nearby obtainable lime is used which was procured from a typical lime dealer. Dry addition technique is used in grounding of lime stabilized samples to attain greatest addition competence. The lime was produced in a daintily pulverized from. This lime is used as a stabilizing agent in all the tests that are auctioned on the soil sample. In table 3.2 shows Chemical composition of lime.

Table 3.2 General chemical composition of lime

Component	Formula	Typical%
Calcium Oxide	CaO	20-60
Silica: Amorphous	SiO_2	10-60
Silica: Crystalline	SiO_2	1.8-3.2
Alumina	Al_2O_3	0.5-21
Titanium Oxide	TiO_2	0.33-2
Ferric Oxide	Fe_2O_3	1-14.5
Magnesium Oxide	MgO	0.5-10

Consolidation learning is formed on "Terzaghi theory of one dimensional consolidation characteristics of soil samples".

3.3 Electrolyte solutions (Pore fluids).

Consolidation behavior for electrolyte solutions (pore fluid) such as distilled water was used along with increment in lime content in the molded samples to determine the leaching of lime in the leachet and another set of tests were carried out with electrolyte solutions such as distilled water(DW),1N Sodium chloride (NaCl), 1N Potassium Chloride (KCl) and 1N Calcium chloride ($CaCl_2$) which were used as passing solutions(pore fluids), for un stabilized and 10% lime stabilized samples to find the possible leaching and replacement of ions in the soil.

4. EXPERIMENTAL PROGRAM

The natural soil, when compacted will have maximum density and strength at optimum moisture content. As mentioned in the earlier sections, people have attempted lime stabilization either by mixing lime to the soil and compact it to optimum moisture content of the soil or by injecting lime slurry in to the ground. In the first case water available may be insufficient for the reactions between soil and lime. Hence it becomes essential to fix up optimum lime content along with optimum moisture content for unstabilized soil.

4.1 Selection of soil sample

Sl.No	Particulars	Remarks
1	Black cotton soil	Bhalki area (Bidar)

4.2 Consolidation test

Test is performed to determine the magnitude of compression and rate of volume change behavior of the selected unstabilized and stabilized B.C soil, when subjected to different vertical pressures and different passing pore fluids. From the measured data, the consolidation curve (Pressure-void ratio relationship) can be plotted. This data is useful in determining the compression index, and coefficient of consolidation for unstabilized and stabilized soils.

4.3 Test procedure

1st set experiment: To determine Cv and Cc.

The test procedure is as per As per IS 2720 part XV, 1986. (unstabilized soil)

a) Beginning of test

Sl.No	Particulars	Values
1	Specimen ring: (i) Diameter (mm) (ii) Height, Hi (mm) (iii) Area, A (mm2) (iv) Volume, V (mm3)	 60 20 2827.43 56548.67
2	Mass of ring (g)	178

b) End of test

Sl. No.	Particulars	Values
1	Mass of ring +wet specimen (g)	256.00
2	Mass of ring +dry specimen (g)	236.00
3	Mass of water (g)	20.00
4	Mass of dry specimen, Ms (g)	58.00
5	Water content, wf' (%)	34.48
6	Specific Gravity Gs	2.70
7	Height of solids, Hs= Ms/GsA (mm)	7.6

c) Data for e-log p curves

Data for e-log p curves:0% lime					
Applied Pressure	Final Reading	Change in Ht	Specimen Height	Height of solids (mm)	Voids Ratio
	(mm)	ΔH (mm)	Hf= H_i'±ΔH (mm)	H=Hf-Hs (mm)	ef=(Hf-H_s)/H_s
0.000	3.440		20.00	12.40	1.632
5.000	3.452	-0.012	19.98	12.38	1.630
10.000	3.431	0.021	19.96	12.36	1.627
25.000	3.041	0.390	19.57	11.97	1.576
50.000	2.612	0.429	19.14	11.54	1.519
100.000	1.927	0.685	18.46	10.86	1.429
200.000	0.909	1.018	17.44	9.845	1.295
400.000	-0.212	1.121	16.32	8.724	1.148
800.000	-1.352	1.140	15.18	7.584	0.998
0.000	-0.076	-1.276	13.90	6.308	0.830

Cc can be calculated from the graph

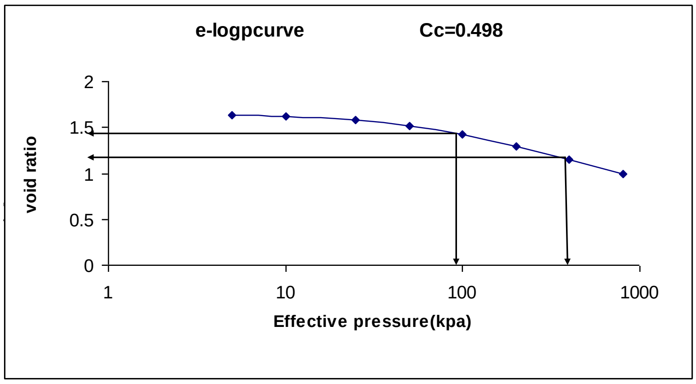


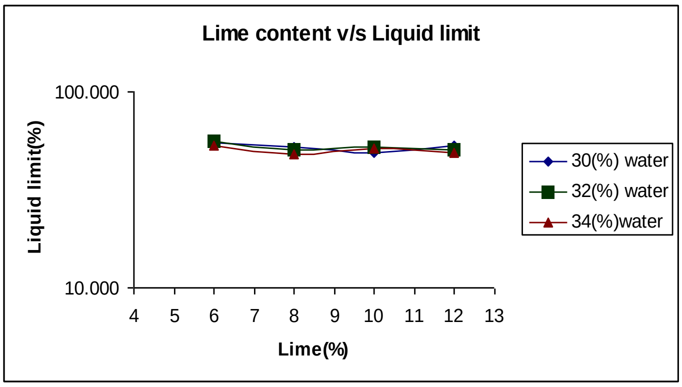
Fig 4.1 Plot for log of effective pressure v/s void ratio.

5. RESULTS AND DISCUSSION

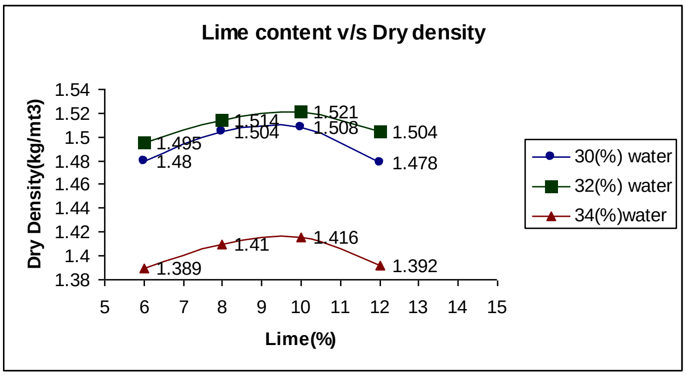
Engineering properties of lime stabilized soil with different percentage of water.

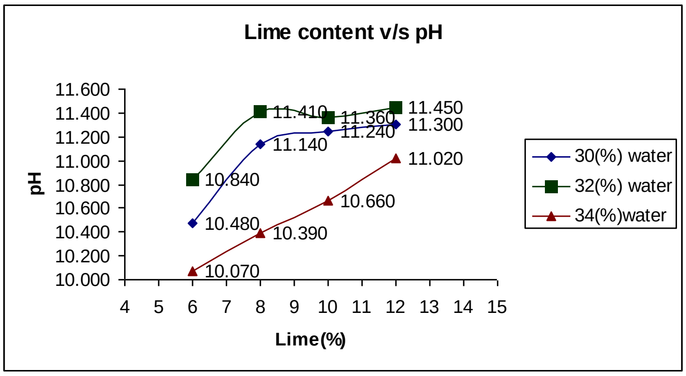
Water content (%)	Lime content (%)	Liquid limit (%)	Dry density Kg/mt 3	Compressive strength (7 days) kg/cm2	pH
30%	6	54.85	1.48	8.115	10.48
	8	52.42	1.504	9.735	11.14
	10	49.2	1.508	11.4	11.24
	12	52.8	1.478	11.97	11.3
32%	6	55.7	1.495	5.15	10.84
	8	50.6	1.514	11.44	11.41
	10	52.2	1.521	14.3	11.35
	12	50.35	1.504	11.685	11.45
34%	6	53.65	1.389	5.05	10.07
	8	48.33	1.41	5.435	10.39
	10	51	1.416	6.275	10.66
	12	48.82	1.392	5.85	11.02

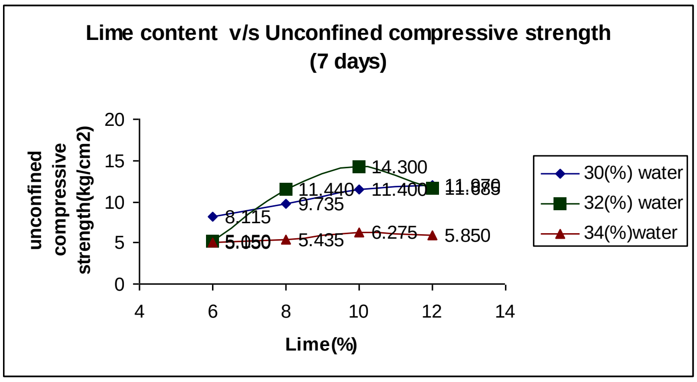
These are expressed in the graphs as shown below.



Influence of Percentage lime on Liquid limit







Influence of lime on UCS

6. CONCLUSIONS

1) The liquid limit of the unstabilized soil was 65.8% when the soil was treatedWith 6% lime it was decreased to 54.8% it shows, the increase in lime content decreases the liquid limit of soil. Beyond the optimum lime content the liquid limit increases.

2) The addition of lime generally increases the amount of pozzolanic reaction and hence increase the strength. The addition of lime up to optimum 10% increasesthe pozzolanic reaction and increases the unconfined compressivestrength. Further increase in lime content beyond optimum lime content decreases the UCS of soil due to excess lime which will not participate in the reaction process.

3) The pH is not the parameter to decide the design lime content for the soil stabilization

4) The soil parameter Cv does not follow any trend till the end of Ist set of experiment. This indicates that the clay-lime mechanism is still undergoing modification phase which shows variation in the Cv values.

5) Lime stabilization improved the consolidation characteristics by reducing the voids on addition of lime. The soil particles aggregate hence the voids are reduced.

6) Reduction in settlement was achieved with lime stabilized soil.

7) The leachet from different lime stabilized samples showed lower concentration of ions with increase in the load which proved the Guoy-Chapman theory.

8) When the unstabilized soil and 10% lime stabilized soil were passed with various pore fluids, the Na+ions and K+ ions showed the replacement by Ca++ ions. This indicated that divalent cations replaced monovalent cations.

9) There was leaching of Ca++ ions only when excess of Ca++ ions provided through pore fluids and also when they were not completely utilized in the stabilization process as the process is a long term reaction.

10) The load increment influenced the reduction in ion concentration up to certain extent as the increment in loading enhanced the rate of reaction by reducing the voids.

REFERENCES

1. Talor, D.W. Fundamentals of soils mechanics, Asia publishing house, New Delhi, 1964.
2. Chemical and lime stabilization ,Yohannes Argu, January 2008.
3. Lal, R. and Shukla, M.K, principles of soil physics, Maracel Decker Inc., New york,2004.
4. Bell.F.G, Stabilization and treatment of clay soils with lime, Part-I, Basic principles, Ground Engineering, 21, 1988, pp 10-15.
5. Sridharan.A, Prakash.K and Asha.S.R, Consolidation behavior of soils, Geotechnical testing Journal, GTJODJ, 18(1), March 1995, pp 58-68.
6. Robinson.R.G and Allam.M.M, compression index of clays and silts, JTE, ASTM, 31 (1), 2001. pp 22-27.
7. Al-Khasab,Mohammed Nather,2007-2008.Stablization of clayey soilsmodified by lime-with an emulsified asphalt addition.
8. Mixture design and testing protocol for lime stabilized soils –vol-3-Dallas.N.Little March-2000.
9. Bolt, G.T. (1956). "Physicochemical analysis of the compressibility of pure clays". Geotechnique, London, 6(2), 86-93.
10. Burland, J.B. (1990). "On compressibility and shear strength of natural clays". Geotechnique, 40, No.3, 329-378.