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Stabilization of Expansive Soil by Adding Lime

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ABSTRACT: The design foundation on black cotton soil has always been a difficult task for the engineers as the structure resting on BC soil cracks without any warning. The properties of BC soil can be modified by stabilizing the soil with the use of additives or by mechanical means. This project deals with the study on strength improvement of expansive soil by adding lime. The experimental work can be carried out with different percentages of lime (5%,10%,15%) on test for atterberge limits, compaction test, CBR test and UCS test. The aim is to improve the engineering properties of the black cotton soil such that the structure built on this soil can be efficiently withstanding applied loads. It was found that the engineering properties of black cotton soil substantially improved by addition of lime.

Keywords: *expansive soil,lime,soil stabilization*

I. INTRODUCTION

1.1 EXPANSIVE SOIL

Expansive soils are soils that expand when water is added, and shrink when they dry out. Expansive soil contains minerals such as smectite clays that are capable of absorbing water. When they absorb water, they increases in volume. In dry season because of the evaporation they shrink out. This soil contains essential clay minerals as montmorillonite. This change in volume can exerts enough force on a building or other structure to cause damage. For the prevention of that stabilization is necessary. Expansive soil or swelling soil of India are commonly known by the name BLACK COTTON SOIL.(11) Expansive soil are found in Africa, south America, US, Indonesia and some countries in Europe .Central India and Deccan plateau mainly constitutes this type of soil, The soil is suitable for growing cottons. This soils cover an extensive area of 3,00,000 km^3.

1.1.1 Properties of expansive soil

1. High Compressibility: Black Cotton soils are highly plastic and compressible, when they are saturated. Footing, resting on such soils under goes consolidation settlements of high magnitude.
2. Swelling a structure built in a dry season, when the natural water content is low shows differential movement as result of soils during subsequent wet season. This causes structures supported by such swelling soils to lift up and crack.
3. Shrinkage a structure built at the end of the wet season when the natural water content is high, shows settlement and shrinkage cracks during subsequent dry season.(7)

1.1.1.1 Engineering properties of black cotton soil

The main engineering properties of soil are permeability, plasticity, compaction, compressibility and shear strength.

a) Permeability

The permeability is defined as the property of a porous material which permits the passage or seepage of water through its interconnecting voids.

b) Plasticity

It is defined as the property of a soil which allows it to be deformed rapidly, without elastic rebound, without volume change.

c) Compaction

Compaction is a process by which the soil particles artificially rearrange and packed together into a closer state of contact by

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mechanical means in order to decrease the porosity of the soil and thus increase its dry density.

d) Compressibility

The property of soil mass pertaining to its susceptibility to decrease in volume under pressure is known as compressibility.

e) Shear Strength

This is the resistance to deformation by continuous shear displacement of soil particles or on masses upon the action of a shear stress.[7]

1.1.1.2 Index properties of soil[7]

Table 1.1 Index properties of soil

Sr.No.	Property	Value
1	Dry density	1300-1800 kg/m^3
2	Liquid limit	40-120%
3	Plastic limit	20-60%
4	Specific gravity	2.6-2.75
5	OMC	20-35%
6	Free swell index	40-180%
7	Swelling pressure	50-800kN/m^2
8	CBR	1.2-4.0
9	Compression index	0.2-0.5

1.2 LIME

Lime is a calcium containing inorganic material in which carbonates, oxides, and hydroxides predominate. Lime is calcium oxide or calcium hydroxide.

1.2.1 Fat lime

Fat lime which is also called stone-lime or white lime is high calcium lime with about 6 per cent material insoluble in acid, chiefly obtained by burning (called calcination) in a kiln pure limestone, chalk or sea shells, etc. (calcium carbonate). By burning calcium carbonate, carbon dioxide is driven off as a gas leaving calcium oxide or quick-lime in the form of lumps. When water is poured over quick-lime it almost immediately cracks, swells and falls into powder with a hissing and creaking sound, slight explosions and considerable evolution of heat and steam. The process is called slaking or hydration, and the powder produced is called hydrated lime or slaked lime (calcium hydroxide). Quick-lime should be slaked as early as possible after it is burnt in a kiln. Over-burnt or under burnt pieces or lumps should be picked out and removed before slaking.

II. MATERIALS

2.1 Soil

Black Cotton soil has major problem of swelling and shrinkage therefore it is problematic for construction. The black cotton soil has been collected in our project is from Maliba Campus (besides from Shrimad Rajchandra College Of Physiotherapy).

Table 2.1 Properties of black cotton soil

Specific gravity	2.70
Gravel (%)	27.88
Sand (%)	70.39
Silt (%) + Clay (%)	1.73
IS classification	OI
Liquid limit (%)	46.7
Plastic limit (%)	31
Plasticity index (%)	15.7
OMC (%)	18
MDD %(gm/cm^3)	1.72
UCS (kN /m^2)	0.47
CBR (%)	2.35

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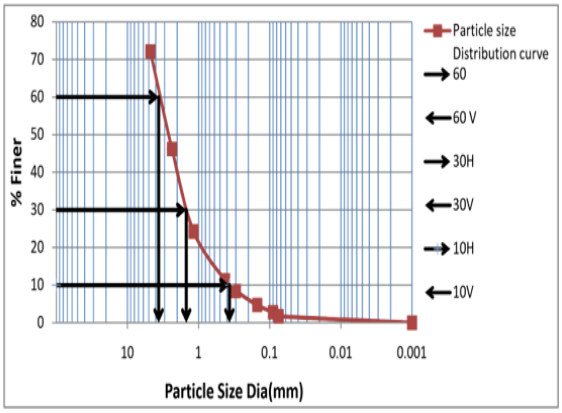


Figure 2.1 soil classification

From the graph of soil classification shown in fig.2.1 the value of particle size diameter is obtain corresponding to 10%, 30% and 60% as follow

D_{10}=0.3681
D_{30}=1.488
D_{60}=3.638
CU=D60/D10 =9.88
$C_C=D_{30}^2/(D_{30}D_{10})$ = 1.65

2.2 Lime

Lime powder was collected from Mahavir Hardwere, Gunjan Chok (Vapi)

Table 2.2 Chemical composition of lime

Chemical Component	Percentage
CaO	48%
SiO_2	6.54%
Al_2O_3	1.15%
Fe_2O_3	1.2%

3 RESULT

3.1 LIQUID LIMIT TEST

Table 3.1 Liquid Limit Test

	B.C.Soil		B.C.Soil+ 5% lime		B.C.Soil+10% lime		B.C.Soil+15% ime	
Sr.No.	W%	N	W%	N	W%	N	W%	N
1	44	60	40	30	35	40	32	45
2	46	27	42	18	37	35	34	39
3	48	15	44	12	40	17	36	14
Total	L.L=46.7%		L.L=41.1%		L.L=38.4%		L.L=34.8%	

3.2 PLATIC LIMIT TEST

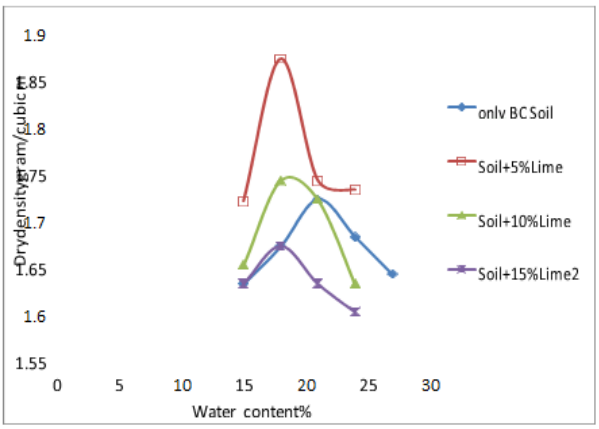
Table 3.2 Plastic Limit Test

Sr No	Composition	Plastic Limit
1	B.C Soil+ 0% Lime	31%
2	B.C Soil+ 5% Lime	Non Plastic
3	B.C Soil+ 10% Lime	Non Plastic
4	B.C Soil+15% Lime	Non Plastic
Plasticity Index = L.L – P.L = 15.3 %		

3.3 COMPECTION TEST

Table 3.3 Compaction

COMPOSITION	OMC	MDD(gm/cm^3)
B.C.Soil+0% lime	18%	1.72
B.C.Soil+5% lime	14%	1.87
B.C.Soil+10% lime	15.5%	1.75
B.C.Soil+15% lime	16.5%	1.67



3.4 UNCONFINED COMPRESSIVE STRNGTH TEST

Table 3.4.1 UCS Result 1 Day

COMPOSITION	Load(kN)
B.C.Soil+0% lime	0.4
B.C.Soil+5% lime	0.88

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B.C.Soil+10% lime	1.67
B.C.Soil+15% lime	1.64

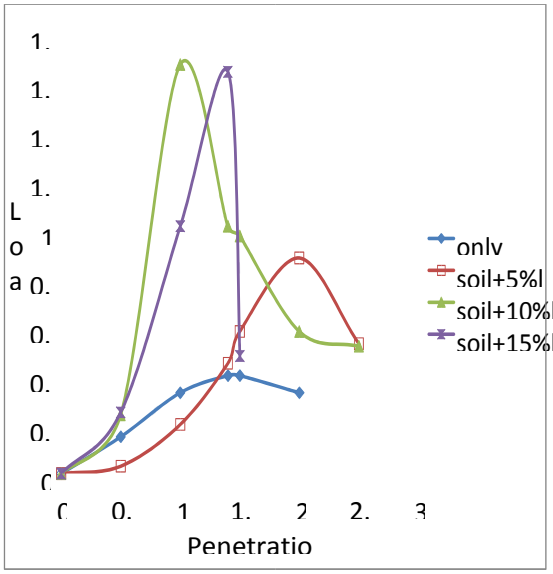

Figure 3.4.1 UCS Test (1st Day)

Table 3.4.2 UCS Result 7 Day

COMPOSITION	Load(kN)
B.C.Soil+0% lime	0.47
B.C.Soil+5% lime	0.76
B.C.Soil+10% lime	1.04
B.C.Soil+15% lime	2.55

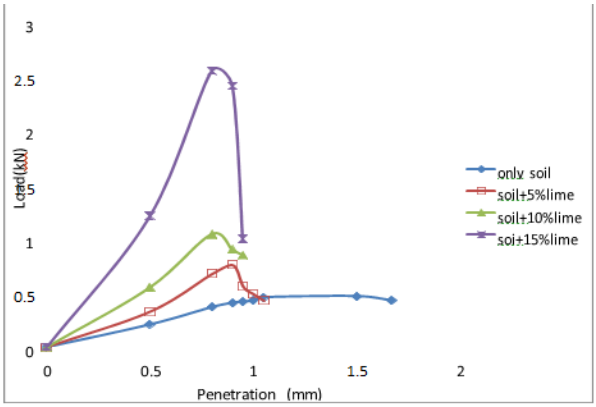

Figure 3.4.2 UCS Test (7th Day)

Table 3.4.3 UCS Result 14 Day

COMPOSITION	Load (kN)
B.C.Soil+0% lime	0.47
B.C.Soil+5% lime	0.93
B.C.Soil+10% lime	1.71

B.C.Soil+15% lime	2.79

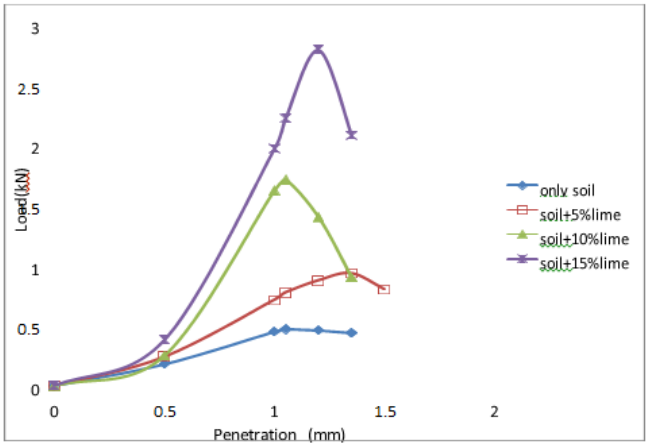

Figure 3.4.3 UCS Test (14th day)

Table 3.4.4 UCS Result 28 Day

COMPOSITION	Load (kN)
B.C.Soil+0% lime	0.32
B.C.Soil+5% lime	1.8
B.C.Soil+10% lime	3.14
B.C.Soil+15% lime	3.28

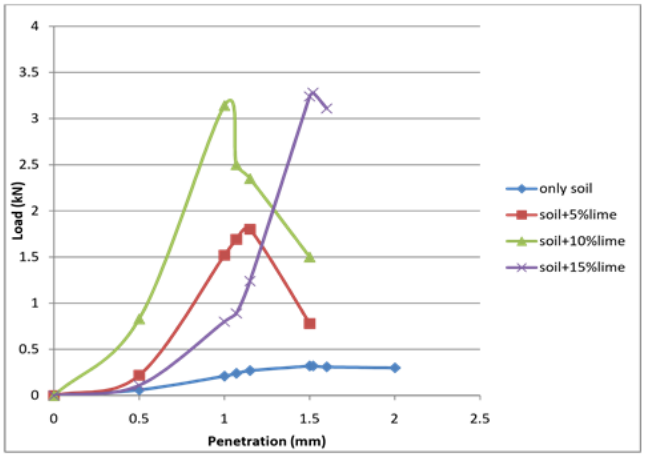

Figure 3.4.4 UCS Test (28th day)

3.5 CALIFORNIA BEARING RATIO (CBR) TEST

Table 3.5 CBR Test

COMPOSITION	CBR Value(%)
B.C.Soil+0% lime	2.35
B.C.Soil+5% lime	4.53
B.C.Soil+10% lime	6.47

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B.C.Soil+15% lime	3.34

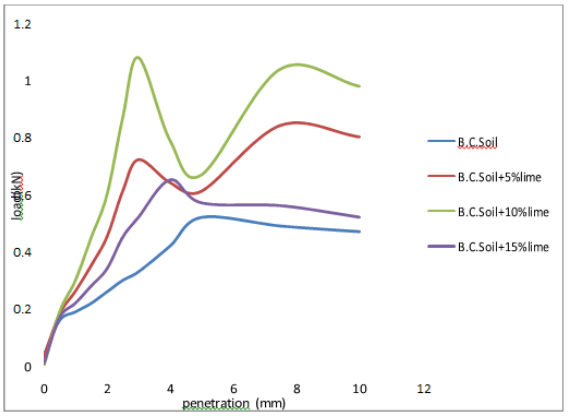

Figure 3.5 CBR Test

IV. CONCLUSION

In this project work, it has been found that the properties of black cotton soil get effectively modified by different proportion of lime. In this experimental work stabilization of soil has been carried out by mixing lime in varying percentages (5%, 10%, 15%). The major conclusion drawn at the end of this work are as follow:

1. *It has been found that an addition of 5% lime decreases the liquid limit by 15.56% ,while 10% and 15% addition of lime shows decreases of liquid limit by 17.77% and 25.48% respectively.*
2. *MDD is found to increase 8.72% and 1.74 % at 5% and 10% addition of lime and MDD is found to decrease by 2.9% at 15% addition of lime as compare to black cotton soil.*
3. *It was found that OMC decreases up to 22.2%, 13.88% and 8.33% at 5%, 10% and 15% addition of lime respectively.*
4. *The compressive strength of black cotton soil increases upon the addition of lime. It has been observed that the value of compressive strength increases with increase in curing period of soil and lime mix. A curing period of 28 days is observed to yield the maximum compressive strength of black cotton soil addition with 15% lime.*
5. *The CBR value of black cotton soil increases 1.92, 2.75 and 1.42 times, while addition of 5% ,10% and 15% lime respectively at 2.5 mm penetration.*

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