International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 06 | June-2018 www.irjet.net p-ISSN: 2395-0072

A Study on Soil Reinforced With Deep Mixed Columns

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Abstract - Deep mixed column (DMC) is a stabilization technique which uses cement and other adhesive admixtures as stabilization agent for improving bearing capacity of soil. Most of the literatures reviewed for the study show that weak soil improvement using deep mixing method focus on effect on soil and binder type, water-cement ratio, binder content and replacement area ratio on the properties of improved ground.

The present study is focusing on strength evaluation of a sub grade soil which is reinforced with deep mixed columns.

For the study black cotton is used as an embankment soil which is to be stabilized with deep mixed columns using laterite soil. Cement and lime are used as adhesive binding agents in a fixed amount of laterite soil, which is 5% each. For the strength evaluation of deep mixed columns, deep mixed columns of laterite soil with 5% cement and 5% lime were prepared separately and were tested by placing DCM'S in B.C soil.

Key Words: Black Cotton Soil, Laterite Soil, Cement, Lime, Deep Mixed Column, Load Settlement.

1. INTRODUCTION

The need for ground improvement is to develop engineering properties of weak soils which then provide stability and required bearing capacity. Many types of stabilization techniques are employed for improvement of bearing capacity of ground. Deep mixed column method is employed for reinforcing the soil. For improvement of bearing capacity off soil and to reduce settlement, stabilizing agents are used in this method. Some of the Key benefits of this technique are, it is economical, vibration free, flexible in application, reduces construction time and is environment friendly method. And some of the Typical Applications of this method are, Embankments on soft soils, Bridge foundation and wind turbine foundations, Slope stabilization, Cut-off walls and barriers.

Present study is carried out in Bidar district, where major part is covered with lateritic soil and B.C soil.

There is a network of rail and large growing network of road network which includes national highways and state highways.

The major rail and highway network are built in a area where B.C soil is available. Black cotton soil have complicated Properties such as low bearing capacity, high swelling and shrinking characteristics, Soil contain clay mineral Montmorillonite. As the soil contains iron, lateritic soil is good in engineering properties, laterite soil have high strength. Laterite soil have high permeability, therefore allowing water to pass through it providing good drainage.

In the region where B.C soil is available, lateritic soil is used to build embankment, large amount of lateritic soil is used in replacing the existing soil to required depth, or to build new embankment.

Soil replacement method is applicable when required embankment depth is very low, however when embankment is having large depth, locally available soil is used, when back cotton soil is used for embankment than this embankment is needed to be stabilized, in this case deep mixed column technique can be used which is effective and efficient.

2. EXPERIMENTAL DETAILS

A. Materials:

Black cotton soil:

Soil is collected at Halbarga, from open pit of depth 1 m below ground surface. Soil obtained is black in colour and texture of soil is loam to clay, soil collected has poor to moderate infiltration characteristic.

Lateritic soil:

Soil is collected from Bidar, from an open pit of depth 1 m below ground surface. Soil obtained is brick red in colour, soil collected have moderate to good infiltration characteristic.

Cement:

Ordinary Portland cement 43 grade is used. Cement is binding material which binds course and fine aggregate together.

Lime:

Lime is calcium containing inorganic mineral, i,e lime also is calcium oxide / calcium hydroxide. In this study hydrated lime in powdered form is used, due to its adhesive property.

Table -1: shows Physical properties of soil

SL. N0	Properties	Lateritic soil	B.C soil
1	Specific gravity	2.6	2.3
2	Consistency limit Liquid limit Shrinkage limit Plastic limit	34.5 % 8.2% 18.65% 15.83%	66% 13.5% 50.4% 15.32%
3	IS soil classification	GW	CH
4	MDD (g\cc)	1.98 g\cc	1.60 g\cc
5	OMC (%)	13%	23%

B. Methodology:

Oven dried black cotton soil & laterite soil were subjected to soil tests. Untreated UCS specimens of B.C soil and laterite soil were prepared for each soil and kept for curing periods of 3 days. Laterite soil sample was treated with 5% cement and 5% lime respectively, and UCS specimens of laterite soil were prepared for each proportions and kept for curing periods of 3 days. Deep mixed columns of laterite soil and 5% cement and 5% lime were prepared of dimensions 2.5cm diameter and 30cm height. These columns were kept in air tight desiccators for curing period of 3 day, and then were placed in tank filled with black cotton soil, which is compacted to maximum dry density known in standard proctor test.

Load settlement test is conducted in a steel box with dimension of 40cm* 40 cm with height of 60cm. Taking care of confinement effect the testing tank is taken sufficiently large. Mild steel footing model of size 20cm*20cm with 6mm thickness is placed centrally in tank filled with black cotton soil to determine load carrying capacity off B.C soil reinforced with deep mixed columns of laterite soil. Load carrying capacity of DMCS of cement and lime is compared.

Design of deep mixed column;

Diameter of DMC = 2.5 cm

Spacing between DMC = 3.5D from center to center of DMC.

Number of DMC = 9

Size of footing = 20cm * 20cm

Replacement ratio = 0.07

Percentage of replacement = 7.2%

C. Experimental work:

Following tests were carried out specific gravity test, moisture content test, atterberge limits and standard proctor test for black cotton soil, and laterite soil. Load settlement test for black cotton soil with and without laterite DMCs was carried out.

D. Load Settlement Test:

Test is conducted to examinant the following;

- To analysis the load settlement interaction on B.C soil bed without deep mixed columns.
- To analysis the load settlement interaction on B.C soil bed with DMC made of laterite soil + cement.
- To analysis the load settlement interaction on B.C soil bed with DMC made of laterite soil + lime.

Step 1: About 90 kg of B.C soil sieved through IS 4.75mm sieve is filled in test tank with size of 40cm*40cm with height of 50cm.

Step 2: The soil is filled in three layers and is compacted to achieve density of 1.6 g/cc.

Step 3: The tank is placed in load applying machine, which is a motorized machine with vertically movable platform with different rates which facilitates in measuring the applied load and settlement.

Step 4: A mild steel square model footing of size 20cm×20cm and 6mm thick is attached to lading frame centrally to surface of the soil bed.

Step 5: Load is applied on the soil through footing in universal testing machine. Load and settlement of footing was measured by computer connect to universal testing machine. At a constant rate load is applied on footing.

Step 6: The above procedure is repeated for different deep mixed columns.

3. RESULTS AND DISCUSSION

A. OMC and MDD results for treated for different blending proportions of the soil:

Table 2: Results of OMC & MDD for all treated & untreated soil samples

SL. No	Description	OMC (%)	MDD (g\cc)
1	Laterite soil	13	1.92
2	Black cotton soil	23.5	1.6
3	Laterite soil + 5% cement	18	2.29
4	Laterite soil + 5% lime	23	2.0

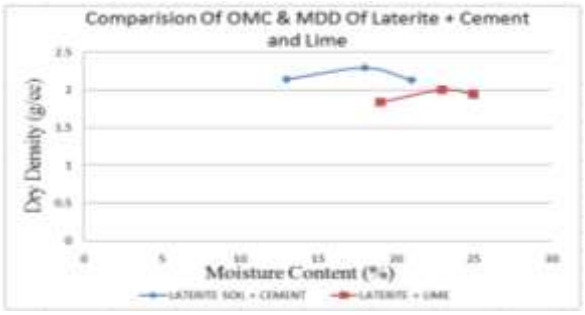

Fig 1. Laterite Soil + 5% Cement And Laterite soil + 5% Lime

B. Unconfined Compressive Strength Results:

Table 3: shows the result of unconfined compressive strength for treated and untreated sample.

Sl.No	Proportions	UCS Of Different Curing Periods (Kg\Cm²)	
		0 day	3 day
1	Laterite soil	2.3	-
2	Black cotton soil	0.77	-
3	Laterite soil + 5% cement	3.5	4.4
4	Laterite soil + 5% lime	3.1	3.9

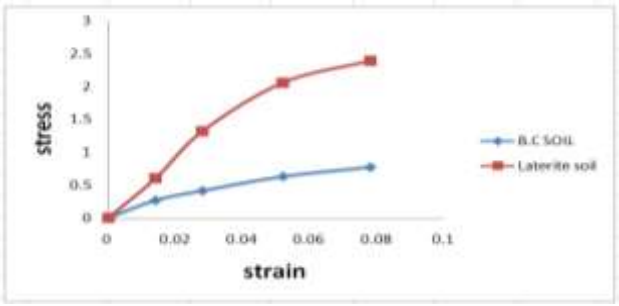

Fig 2. UCS for B.C soil and Laterite

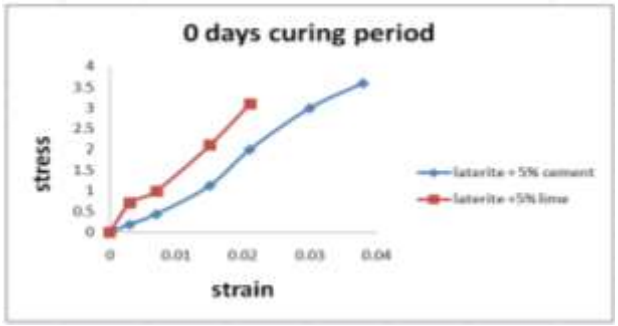

Fig 3. UCS for 0 day curing period.

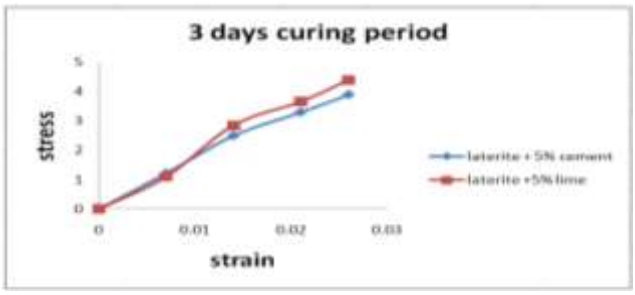

Fig 4. UCS for 3 day curing period.

Load Settlement Test Results:

1. Three tests were conducted for different conditions. First test conducted was on plain black cotton soil bed.
2. Second test is conducted on plain black cotton soil bed reinforced by deep mixed columns made of laterite soil + cement.
3. Third test is conducted on black cotton soil bed by deep mixed columns made of laterite soil + lime.
4. For all the test load settlement behavior was observed.
5. Hence maximum load was considered at 25mm settlement for all the studies

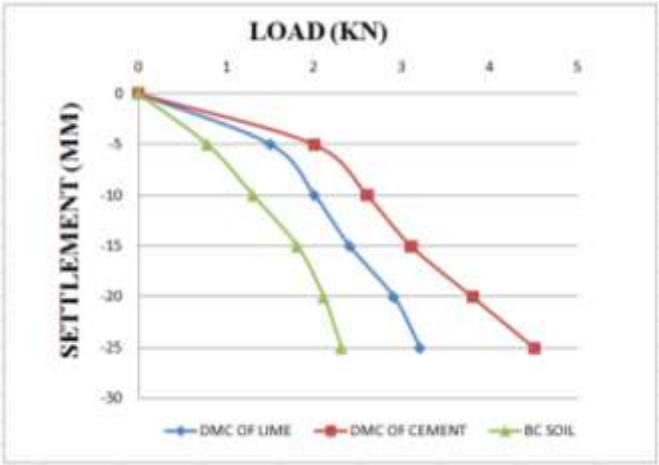

Fig 4. Comparison Of Load Settlement Behaviour For Black Cotton Soil + Deep Mixed Columns Of Laterite Soil + Lime, Laterite Soil + Cement.

For 25 mm settlement of model footing load required is as follows:

B.C soil = 2.3 KN

B.C soil + DMC of lime = 3.2 KN

B.C soil + DMC of cement = 4.5 KN

3. CONCLUSIONS

Following conclusion are been observed from experimental work;

1 Due to use of laterite deep mixed column there is an immense increment of load carrying capacity for B.C soil.
2 Black cotton soil when subjected to load settlement test, for 25 mm penetration of modeled footing in black cotton soil, the load observed is 2.3 KN.
3 When deep mixed columns of laterite soil + lime are used for 25 mm penetration 3.2 KN load is observed.
4 Load carrying capacity was increased to 0.9 KN when deep mixed columns of laterite + lime is used to reinforce black cotton soil.
5 Given 1.5 times the increment in load carrying capacity of black cotton soil reinforced with laterite + lime deep mixed column than that of plain black cotton soil, these DMCS can be used.
6 When deep mixed column of laterite + lime is been used to reinforce black cotton soil than from load settlement test, for 25 mm penetration 4.5 KN of load is observed.
7 Load carrying capacity was increased to 2.2 KN when deep mixed columns of laterite + cement is used to reinforce black cotton soil.
8 On comparing results of laterite + cement and laterite + lime deep mixed columns, load carrying capacity of laterite + cement deep mixed column give higher load carrying capacity & provide strong reinforcement.
9 Hydraulic conductivity of soil increased when lime was used as binding agent in making deep mixed column.

10 For construction of deep mixed columns, when cement is used as binding material give higher strength than that of lime when used as binding material.

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