

Stabilization of Black Cotton Soil with Lime and Geo-grid

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Abstract— Bricks also have been regarded as one of the long lasting and strongest building material used throughout history. Ordinary building blocks are made of a mixture of clay, which is subjected to various processes, different according to the nature of the material, after being properly prepared the clay is formed in moulds to the desired shape, then dried and burnt. The providing affordable housing is a challenge around the world, especially in developing countries. The impediments to solving the housing problem are scarcity of land and high cost of building materials. Furthermore, such materials must be abundantly available and renewable in nature. Local soil has always been the most widely used material for earthen construction. The main objective of this investigation had been focused on the improvement of the compressive strength of the black cotton soil blocks with different content of lime by reinforcing the geo-grid. The rectangular (200mm × 100mm × 100mm) blocks are prepared with soil treated with 5%, 10% and 15% lime with the geo-grid reinforcement at the middle depth of the blocks, the compressive strength of the bricks is obtained by laboratory compression test apparatus the results obtained are compared with unreinforced samples.

Keywords—Black Cotton Soil, Lime, Geo-grid, Compressive strength, Rectangular blocks.

I. INTRODUCTION

Black cotton soil is one of the expansive soils that increases in volume or expand as they get wet and shrink as they dry out. The compressive strength and stability of the soil can be considerably improved by soil stabilization through controlled compaction and the addition of suitable admixtures in some proportion. Swelling and shrinkage property of soil is not suitable for the construction work on account of its volumetric changes.

It swells and shrinks excessively with change of water content. Such tendency of soil is due to the presence of fine clay particles which swell, when they come in contact with water, resulting in alternate swelling and shrinking of soil due to which differential settlement of structure takes place. Stabilization of black cotton soil has been done in this project work by using lime and Geo-grid as admixture.

II. MATERIALS

A. Black Cotton Soil

The soil used in this project is a **Black Cotton Soil** collected from Kolhewadigaon in Pune, Maharashtra State in India. Kolhewadi is located at Latitude 18° 26' 24.29" N and Longitude 73° 47' 10.84" E. The community called the soil '**Kali Mati**'.

The black cotton soil was collected by method of disturbed sampling after removing the top soil at 150mm depth and transported in sacks to the laboratory. Little amount of the sample was sealed in polythene bag for determining its natural moisture content. The soil was air dried and sieved with IS sieve 4.75mm as required for laboratory test.

B. Lime

In this project various percentage of lime (i.e. 5%, 10%, and 15%) is used as admixture.

C. Geo-grid

Geo-grid used in this project is Biaxial Geo-grid shown in figure I and the physical properties of geo-grid are given in table II. The geo-grid reinforcement of size 180mm×90mm is placed at the middle of the rectangular block i.e. at height of 50mm from bottom. Its price ranges between Rs 80/- to Rs 200/- per sq.m. It is not till being manufactured in India.

TABLE II

PHYSICAL PROPERTIES OF GEO-GRID (SUPPLIED BY THE MANUFACTURER)

Physical properties	Coated yarn geo-grid
Aperture size	50.8 mm
Thickness	2 mm
Density	1.12 gram/cm ³
Mass per unit area	0.1 g/cm ²

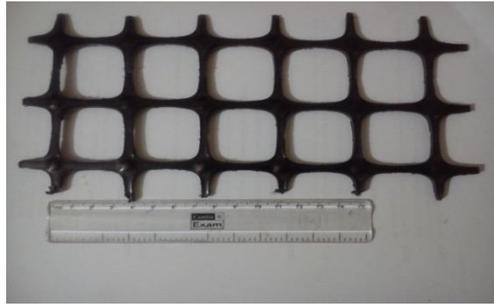


Fig. 1 Geo-grid

III. METHODOLOGY

Index tests on the natural BC soils were carried out in accordance with the procedures outlined in IS 2720, step percentages of lime by dry weight of soil (5, 10 and 15%) was introduced into the soil.

The following tests were carried out on the natural BC soil.

- Natural moisture content test
- Specific gravity (Density Bottle method)
- Atterberg Limits (Liquid limit, Plastic Limit)
- Compaction test (Standard proctor test)
- Compressive Strength test (3, 7, 14, 28 days curing period)

A. Geotechnical Properties

Results of tests carried out on the natural BC soil are summarized in Table II

TABLE II
GEOTECHNICAL PROPERTIES OF THE UNTREATED BLACK COTTON SOIL

Property	Value/description
Specific gravity	2.37
Liquid limit	66.1%
Plastic Limit	36.74%
Plasticity Index	29.36%
Unified Soil Classification System (USCS)	CH
Maximum Dry Density (MDD)	1.2726 kg/m ³
Optimum Moisture Content (OMC)	34.6%
Natural Moisture Content	17.399%
Colour	Dark black

B. Atterberg Limits

Liquid limit = 66.1%

Plastic limit = 36.74%

Plasticity index = 29.36%

Plasticity of black cotton soil was found 29.36%. So according to unified soil classification system (USCS) clay is classified as inorganic clays of high compressibility (CH).

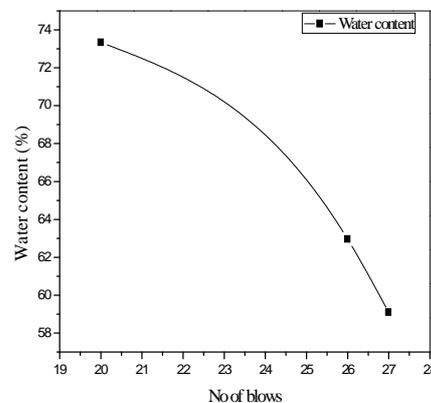


Fig.2 Liquid Limit curve of Black Cotton soil

C. Compaction Test (Standard Proctor Test)

Figure 3 shows the relation between water content and dry density. The optimum moisture content of black cotton soil sample has been found, $W_0 = 34.6\%$ and max. Dry density has been found $(\rho_d)_{max} = 1.2726 \times 10^{-3} \text{ kg/m}^3$.

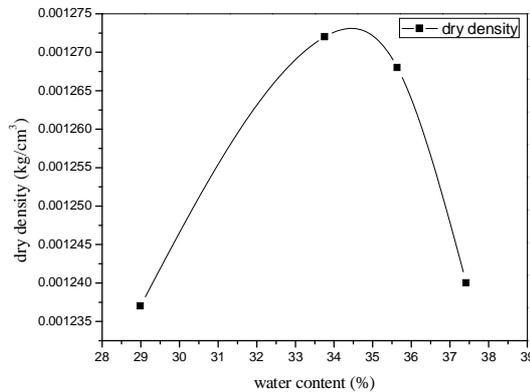


Fig. 3 compaction curve of Black cotton Soil

D. Compression test on BC soil and Lime blocks without Geo-grid

Figure 4 shows variation of compressive strength of BC soil blocks without Geo-grid reinforcement for various days of curing period. The graph is plotted against CS of BC soil blocks without geo-grid reinforcement and % of lime.

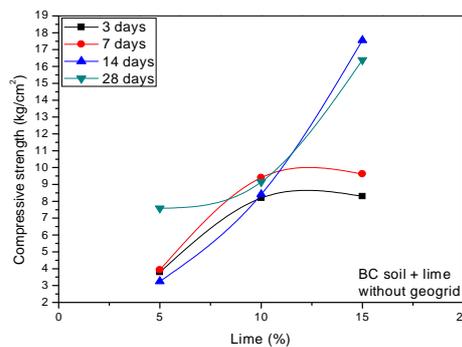


Fig. 4 Variation of Compressive strength of BC soil blocks without Geo-grid reinforcement.

From figure 4 it is observed that,

1. The compressive strength of the rectangular BC soil blocks without geo-grid reinforcement for 5 percent lime content and 3, 7, 14 and 28 days curing period is 3.7897, 3.9258, 3.2460 and 7.5967 kg/cm² whereas for 10 and 15% lime is (i) 8.1916, 9.4037, 8.4125 and 9.1442 kg/cm² (ii) 8.2936, 9.6191, 17.5558 and 16.3831 kg/cm² respectively.
2. For the 15 percent lime content, the maximum compressive strength of the BC soil block is observed as 8.2936 kg/cm², 9.6191 kg/cm², 17.5558 kg/cm² and 16.3831 kg/cm² for 3, 7, 14 and 28 days curing period. The optimum lime content for the BC soil block is 15 percent.
3. The maximum value of CS is given by BC soil blocks with addition of 15% lime after 14 days of curing and the value is 17.5558 kg/cm².

E. Compression test on BC soil and Lime blocks with Geo-grid

Figure 5 shows variation of compressive strength of BC soil blocks with Geo-grid reinforcement. The graph is plotted against CS of BC soil blocks with geo-grid reinforcement and % of lime for various days of curing period.

From figure 5 it is observed that,

1. The compressive strength of the rectangular BC soil blocks with geo-grid reinforcement for 5 percent lime content and 3, 7, 14 and 28 days curing period is 4.8094, 4.7756, 3.7049 and 8.2255 kg/cm² whereas for 10 and 15 percent lime is (i) 7.9876, 11.0807, 11.0637 and 9.4662 kg/cm² (ii) 10.0583, 9.6126, 18.7624 and 22.5014 kg/cm² respectively.
2. For the 15 percent lime content, the maximum compressive strength of the BC soil block is observed as 10.0583 kg/cm², 9.6126 kg/cm², 18.7624 kg/cm² and 22.5014 kg/cm² for 3, 7, 14 and 28 days curing period. The optimum lime content for the BC soil block is 15 percent.
3. The maximum value of compressive strength was obtained for BC soil blocks with geo-grid reinforcement and with addition of 15 % lime for 28 days of curing period. The maximum value of compressive strength is 22.5014 kg/cm²

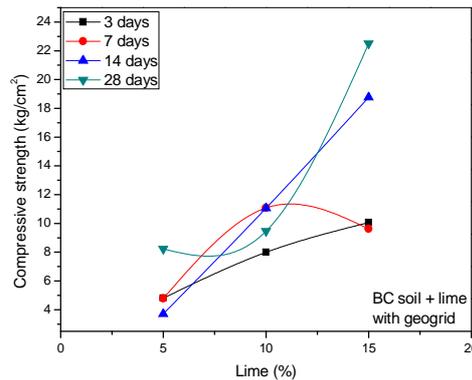


Fig. 5 Variation of Compressive strength of BC soil blocks with Geo-grid reinforcement

F. Comparison of Percentage Increase in Compressive strength with respect to 5% lime content

1) For 3 days of curing period

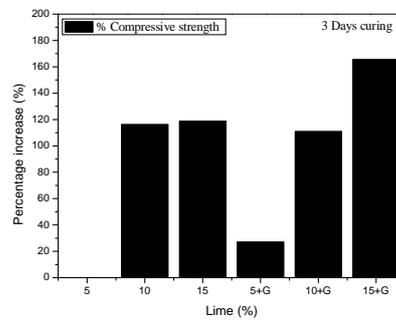


Fig.6 Percentage Increase in compressive strength of BC soil blocks (200mm×100mm×100mm) with respect to 5% lime content for 3 days of curing period

From fig. 6 observed that;

1. The percentage increase in compressive strength of rectangular BC soil blocks (200mm×100mm×100mm) with respect to 5% lime content for curing period of 3 days for 10% , 15%, 5% with geo-grid, 10% with geo-grid and 15% with geo-grid was 116.15%, 118.85% and 26.90%, 110.77% and 165.41% respectively.
2. It has observed that, for 15% addition of lime with geo-grid reinforcement the percentage increased in compressive strength was highest.

2) For 7 days curing period

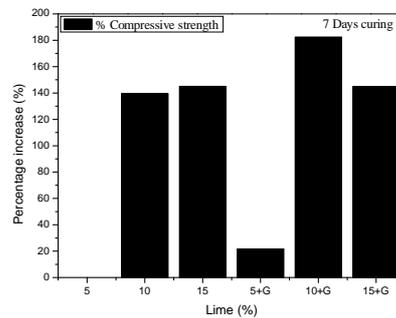


Fig. 7 Percentage Increase in compressive strength of BC soil blocks (200mm×100mm×100mm) with respect to 5% lime content for 7 days of curing period

From fig. 6 observed that;

1. The percentage increase in compressive strength of rectangular BC soil blocks (200mm×100mm×100mm) with respect to 5% lime content for curing period of 7 days for 10%, 15%, 5% with geo-grid, 10% with geo-grid and 15% with geo-grid was 139.54%, 145.02%, 21.65%, 182.25% and 144.85% respectively.
2. It has observed that, for 10% addition of lime with geo-grid reinforcement the percentage increased in compressive strength was highest.

3) For 14 days curing Period

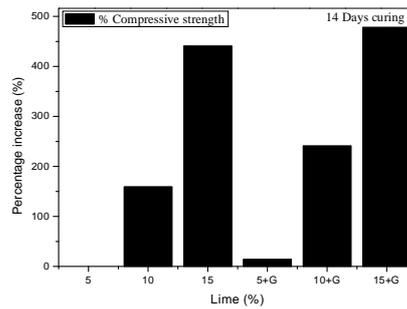


Fig. 8 Percentage Increase in compressive strength of BC soil blocks (200mm×100mm×100mm) with respect to 5% lime content for 14 days of curing period

From fig. 8 observed that;

1. The percentage increase in compressive strength of rectangular BC soil blocks (200mm×100mm×100mm) with respect to 5% lime content for curing period of 14 days for 10%, 15%, 5% with geo-grid, 10% with geo-grid and 15% with geo-grid was 159.16%, 440.84%, 14.13%, 240.84% and 478.01% respectively.
2. It has observed that, for 15% addition of lime with geo-grid reinforcement the percentage increased in compressive strength was highest.

4) For 28 days curing period

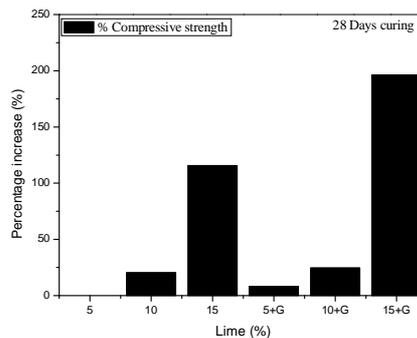


Fig. 9 Percentage Increase in compressive strength of BC soil blocks (200mm×100mm×100mm) with respect to 5% lime content for 28 days of curing period

From fig. 9 observed that;

1. The percentage increase in compressive strength of rectangular BC soil blocks (200mm×100mm×100mm) with respect to 5% lime content for curing period of 28 days for 10% 15%, 5% with geo-grid, 10% with geo-grid, 15% with geo-grid was 20.37%, 115.66%, 8.27% , 24.60% and 196.19% respectively.
2. It has observed that, for 15% addition of lime with geo-grid reinforcement the percentage increased in compressive strength was highest.

IV. CONCLUSIONS

The results of tests conducted on rectangular BC soil blocks (200mm×100mm×100mm), reinforced and unreinforced with geo-grid are presented in chapter 4. Based on the results, following conclusions were drawn.

1. With increase in addition of lime content the compressive strength of BC soil blocks increases.
2. The soil is classified under CH. Liquid limit and Plastic limit values are 66.1 % and 36.74% respectively suggest that the soil is highly compressible. Thus, from the results obtained, the soil falls below the standard recommended for most geotechnical work.
3. Lime and geo-grid is used as reinforcement for improving the geotechnical characteristics of black cotton soils. Lime significantly improves strength characteristics of black cotton soil under study and the effect of lime vary depending upon the quantity of lime that is mixed with the black cotton soil sample.
4. The compressive strength of these soils increases upon the addition of lime. The trend of improvement in the compressive strength is observed to be more pronounced with the curing of the soil and lime mix. A curing period of 28 days is observed to yield the maximum compressive strength of BC soil blocks reinforced with 15% lime content and geo-grid.
5. A curing period of 14 days is observed to yield the maximum enhancement in the compressive strength of BC soil blocks for addition of 15% lime content and geo-grid reinforcement with respect to addition of 5% lime content.

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