ISSN 2347 - 3983
Volume 9. No. 4, April 2021
International Journal of Emerging Trends in Engineering Research
Available Online at http://www.warse.org/IJETER/static/pdf/file/ijeter29942021.pdf
https://doi.org/10.30534/ijeter/2021/29942021

# Stabilization of Black Cotton Soil using Lime and Phosphogypsum

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## ABSTRACT

Expansive soils are problematic soils for Civil Engineers. Black cotton (BC) soils possess low strength and high compressibility, due to these properties black cotton soils are considered to be challenging one for analysis. To achieve desired properties of soil for construction purpose these black cotton soil must be enhanced to meet its requirement. To modify the properties of black cotton soils, many treatment methods are there. In this paper an attempt has been made to improve the properties of black cotton soil by using industrial waste through stabilization method. By stabilizing the soil properties are enhanced and make it suitable for subgrade construction. In this work, the combined effect of Lime and Phosphogypsum (PG) on compaction characteristics, Atterberg's Limit, Unconfined Compressive Strength (UCS) for original soil, California Bearing Ratio (CBR) and direct shear Test of a black cotton soil with percentage varying of Lime and Phosphogypsum was carried out. The soil samples were tested for tri-axial compression test and CBR tests were carried out after 4 days curing period. From the results, it has been inferred that the black cotton soil treated with Lime and Phosphogypsum in the percentages of (4:4) has better strength characteristics. Hence, it may be concluded that Lime and Phosphogypsum can be used for stabilization of black cotton soils for pavement subgrade

**Key words:** Black cotton soil, CBR Value, Direct Shear test, Lime, Phosphogypsum.

## 1. INTRODUCTION

Black cotton soils posture noteworthy issues to structural designing structures, for example, streets built on them may fail due to differential settlements, poor quality and high compressibility. In India specifically in places like Rajasthan, Madhya Pradesh, Gujarat, Andhra Pradesh, Telangana, Karnataka and Tamilnadu have inexplicable store of far reaching soils. These wide-ranging soils are colloidal soils containing 2µ earth part fluctuating half to 70% comprising of noteworthy parcel of Montmorillonite and Illite minerals. When compare to all soil types, black cotton soil is a very broad as it shows high swelling, shrinkage, compressibility and poor quality in contact with water, particularly amid blustery season prompting splits in overlying street asphalts. In the course of recent years, huge research has been conducted by various authors on treatment strategies to balance out delicate and extensive soils.

Taking into account the component of soil change, adjustment strategies can separate into physical, mechanical, and compound adjustment [14]. Amongthese mechanical and substance adjustment strategies are much of the time utilized since they give quick, productive, repeatable and solid changes to soil properties [15]. In spite of the fact that these strategies are viable, still there is a need for use of squanders as settling materials which conservative as well as fathoms the transfer issue of squanders. Along these lines, the present study has been completed.

Phosphogypsum can likewise be perceived as a potential soil settling agent or as an stabilizing operator. An extensive amount of mechanical by-product material, for example, Phosphogypsum is being created prompting transfer, natural and well-being issues [4] and [5]. Numerous research studies are available on the stabilization of black cotton soils utilizing lime alone and exceptionally constrained studies utilizing Phosphogypsum as a part of the writing. In this manner, the introduce work did to think about the impact of lime and Phosphogypsum on designing properties, for example, compaction, unconfined compressive quality, consistency limits and the California bearing ratio and tri-axial compression test of Black Cotton soil.

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### *1.1 Objectives of Work*

The standard points of the work reported in this statement are as per the following:-

a. To study the effect of lime and Phosphogypsum blend on the geotechnical qualities of black cotton soil
b. To explorate the mineralogical and morphological changes operating at a black cotton soil due to adjustment utilizing lime and Phosphogypsum combined mixture.
c. Variation of Strength of soil at different water content.
d. Effect of lime on CBR value of the soil.
e. Effect of lime on Compressive strength of soil.

## 2. LITERATURE REVIEW

**Sujeet Kumar et al., (2014)** watched that dry unit weight, optimum water content , liquid limit, plastic limit,% swell, of soil mix with Bentonite + 8% lime on expansion of 8 % PG expanded and free swell record diminished. Also, watched diminish in UCS past 8% expansion of PG where CV has no impact on expansion of PG. Additionally CBR, the modulus of the subgrade response and secant modulus expanded for the Bentonite balanced out with lime and PG which helps in decrease in earthwork, required thickness of subgrade Bentonite. Conduct of the Bentonite-lime-PG combined will help the development of pavements on expansive soils [7] and [8].

**Sleiman M. Al-Zaidyeen and Arabi N. S. Al-Qadi (2015)** directed tests to understand the impact of PG as a waste material in soil adjustment of pavement layers which demonstrated that the potential quality of the clay soil expanded with the expansion in the PG up to 20% from CBR test. What's more, ideal % of PG to be added to silty or clayey rock and sand soil is favoured as 21.4%. Additionally presumed that in asphalt development by utilization of PG asa stabilizer could lessen the depth of asphalt layer [6].

## 3. MATERIALS AND METHODOLOGY

### *3.1 Materials*

Black cotton soil (BC Soil) was collected from site near the “AVADI RAILWAY STATION” surroundings in CHENNAI. The soil sampling was done at a depth of 1.0m below the ground level. The standard proctor compaction test results shows optimum moisture content (OMC) is 26% and maximum dry density (MDD) is 1.51g/cc. The lime used in the present project was purchased from the local market in Chennai, Tamilnadu. A common term for burned limestone also known as quicklime, hydrated lime and un slaked lime or slaked lime. Phospogypsum used in this study was collected from udhaya chemicals which is located in Chennai.

### *3.2* **Methodology**

In this study the properties of black cotton soil suchthat index and engineering properties were analysed. From the index and engineering properties the soil was found to be having very low strength and expansive in nature. Soil stabilization with lime and Phospogypsum was chosen in order to improve the properties of soils [1], [2] and [3]. The process of improvement in properties of black cotton soil split into two stages.

The first stage dealt with finding the optimum content calcium carbide residue (lime) from the following tests as given here, Atterberg Limits, Standard Proctor Compaction Test, Unconfined Compressive Strength Test, Direct shear test and California Baring Ratio Test.
These tests involved in addition of different percentages of lime (2%, 4%, 6%, 8%, 10%, 12%, 14%, 16%, 18%, 20% and 22%) to the expansive soil. The lime was thoroughly mixed with soil by hand until homogeneity was reached. Atterberg’s limits tests carried out with addition ofvarying percentages of lime (2%, 4%, 6%, 8%, 10%, 12%, 14%, 16%, 18%, 20% and 22%). Standard proctor compaction tests carried out with addition of varying percentages of lime (2%, 4%, 6%, 8%, 10%, 12%, 14%, 16%, 18%, 20% and 22%). The unconfined compressive strength and California baring ratio test was conducted for original Black Cotton soil only. The direct shear, consolidation and California baring ratio tests were conducted with lime percentages of (2%, 4%, 6%, 8%, 10%, 12%, 14%, 16%, 18%, 20% and 22%). California bearing ratio tests were carried out with 4 days soaking.

The second stage of this study dealt with the obtaining the test values and California bearing ratio by fixing 4% lime and % varying of Phospogypsum (10%, 20%, 30%). The UCS tests carried for only soil. The CBR tests were carried out with soaked periodof 4 days.

## 4. RESULTS

### 4.1 *Experimental Investigation on Soil Sample*

**Table 1: Properties of the black cotton soil**

| Properties | Result |
|---|---|
| Water Content (%) | 28.3% |
| Specific Gravity of Soil | 2.38 |
| Permeability (cm/s) | $7.1 \times 10^{-5}$cm /s |
| Liquid Limit (%) | 52% |
| Plastic Limit (%) | 30.67% |
| Plasticity Index | 21.33% |
| Optimum Moisture Content | 26% |
| Maximum Dry Density | 1.51g/cc |
| Effective size, $D_{10}$ | 12µ |
| Uniformity coefficient, $C_U$ | 5.83 |
| Coefficient of curvature,$C_c$ | 0.744 |

### *4.2 Atterberg Limit's*

**Table 2: Variation of Liquid Limit (LL), Plastic Limit (PL) & Plasticity Index (PI) with adding of Lime in %**

| L (%) | LL (%) | PL (%) | PI (%) |
|---|---|---|---|
| 0 | 52 | 30.67 | 21.33 |
| 1 | 49.2 | 29.72 | 19.48 |
| 3 | 47.6 | 28.64 | 18.96 |
| 5 | 45 | 28.07 | 16.93 |
| 10 | 43 | 29.6 | 13.4 |
| 15 | 42.4 | 30.13 | 12.27 |
| 20 | 39.6 | 30.47 | 9.13 |
| 25 | 40 | 30.56 | 9.44 |
| 30 | 40 | 30.78 | 9.22 |

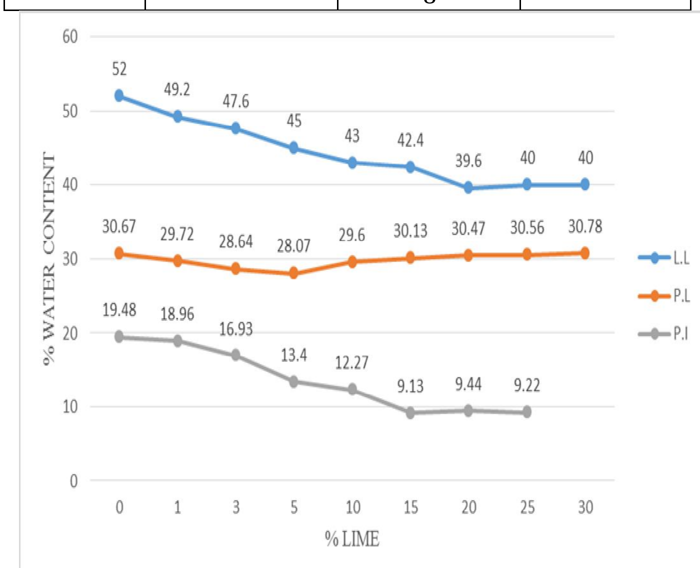


**Figure 1: Atterberg Limit for Various % of Lime**

**Table 3: Variation of LL, PL & PI with adding of 20% of Lime + Varying % of PG**

| Mixture Variations | LL % | PL % | PI |
|---|---|---|---|
| 20% lime +10% PG | 36 | 28.75 | 7.25 |
| 20% lime +20% PG | 32 | 26.216 | 5.78 |
| 20% lime +30% PG | 30 | 24.6 | 5.40 |

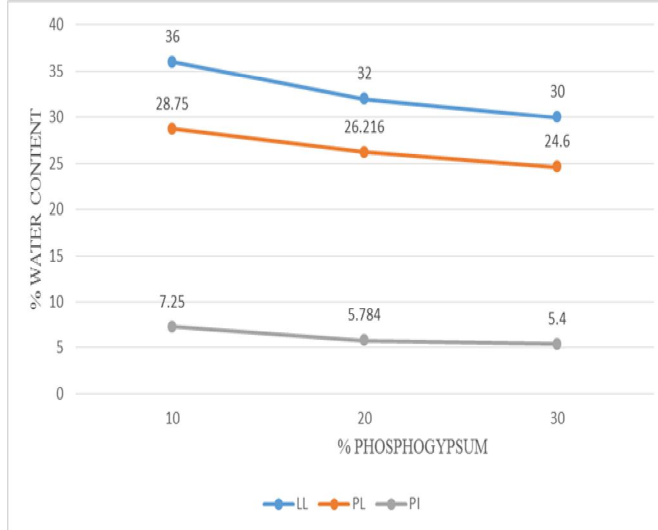


**Figure 2: Atterberg Limit for 20% Lime +Varying % of PG**

### *4.3 Standard Proctor Test*

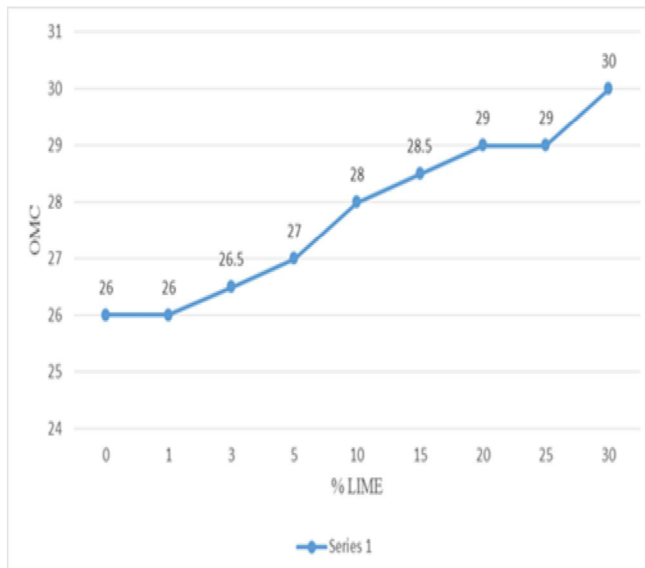


**Figure 3: Compaction curves for BC Soil + Varying % of Lime**

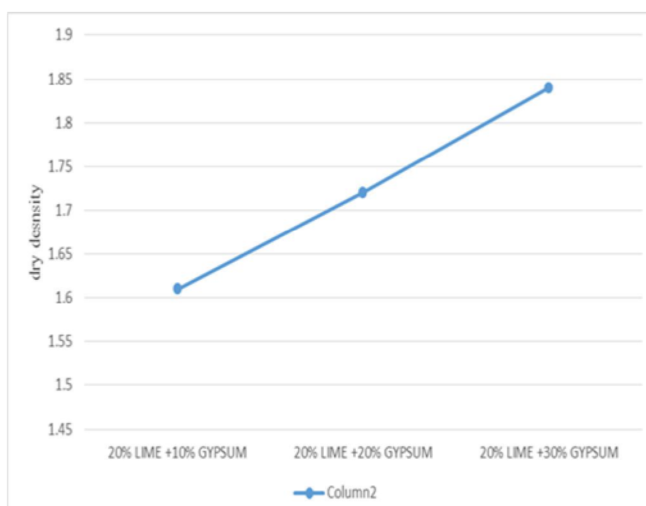


**Figure 4: Compaction curves for BC Soil + 20 % of Lime +**

**Varying % of PG**

### *4.4 California Bearing Ratio Test (CBR)*

**Table 4: Variation of CBR Soaked & Un-soaked value for BC soil + 20% Lime + Varying % of PG**

| Mixture variations | Un-Soaked CBR Value | Soaked CBR Value |
|---|---|---|
| 20%lime + 10% PG | 4.61 | 3.24 |
| 20%lime + 20% PG | 5.89 | 4.1 |
| 20%lime + 30% PG | 5.46 | 3.41 |

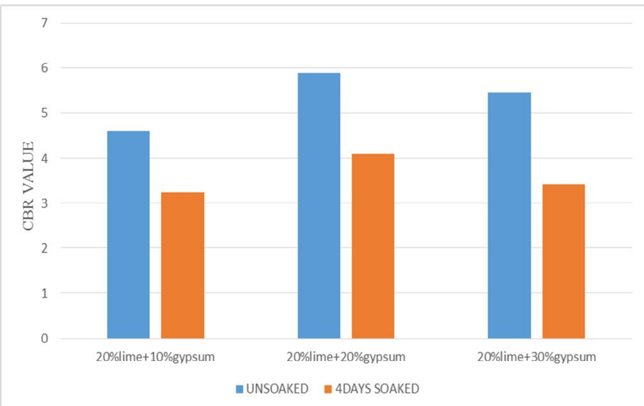


**Figure 5: Variations of CBR Soaked and Un-soaked for BC Soil + 20% Lime +Varying % of PG**

Figure 1 shows the variations of Atterberg's limit for various % of lime and Figure 2 shows the variations of Atterberg's limit for optimum lime with various % of PG. Figure 3 illustrated the compaction curve for BC soil with varying % of lime. Whereas Figure 4 represents the compaction curve for BC soil with optimum lime and Varying % of PG.

The soil samples collected from the study area is analyzed and its properties are arrived using standard procedures suggested by BIS [9], [10], [11], [12] and [13] and tabulated in Table 1.

Table 2 shows the variations of Atterberg limits for different proportion of lime added to soil. Similarly in Table 3, the LL, PL, PI values are tabulated for optimum lime content and varying % of PG.

CBR test is conducted for both soaked and un-soaked samples with optimum lime and varying % of PG and its results are tabulated in Table 4.

Figure 5 shows a bar chart which illustrates the variations of CBR values for both soaked and un-soaked soil samples. Trials are conducted with optimum lime content with varying % of PG.

## 5. CONCLUSIONS

The following conclusions has been drawn on the basis of the results obtained and discussion made on this study as given below

1. With addition of lime, there is a considerable decrease in Atterberg's Limits, and after 20% the value seems to be almost constant.
2. OMC increases and maximum dry density decreases with increase inpercentage of lime.
3. With addition of varying % of lime cohesion decreases and angle ofinternal friction increases.
4. Shear strength increases with increase in percentage of lime and after 20% strength is almost constant.
5. Permeability increases with increase in lime.
6. Coefficient of consolidation increases and compression index decreases with increase in percentage of lime.
7. From the analysis it is found that 20% of lime gives considerable improvement in properties of clay soil. So 20% has been selected as optimum percentage.
8. Maximum dry density increases and optimum moisture content decreases considerably with addition of optimum percentage of lime and varying percentage of PG.
9. Shear strength and angle of internal friction increases and cohesion decreases with addition of optimum percentage lime and increase in percentage of Phosphogypsum.
10. Atterberg's limits decreases considerably with addition of optimum percentage of lime and gypsum. PI is almost constant for 20% and 30% PG with optimum

percentage of lime. Hence 20% lime & 30% PG is selected as optimum percentage.


## ACKNOWLEDGEMENT

The authors thank Panimalar Engineering College, affiliated to Anna University, Chennai for supporting us to utilize Institutional facilities to carry out research work in a Fruitful manner.


## REFERENCES


1. Ankit Singh Negi, Mohammed Faizan, Devashish Pandey Siddharth, Rehanjot singh, **Soil stabilization using Lime**, *International Journal of Innovative Research in Science, Engineering and Technology*, Vol.2(2), pp.448-453, 2013.
2. Ameta. N. K, Purohit. D. G. M, Wayal A. S, Dangda Sandeep (2007), **Economics of Stabilizing Bentonite Soil with Lime-Gypsum**, *Electronic Journal of Geotechnical Engineering*, Vol.12, pp.1-8, 2007.
3. DivyaKrishnan.K, Janani.V, Ravi chandran .P.T, Annadurai.R, Manisha Gunturi, **Effect of Fly Ash and PhosphoGypsum on Properties of Expansive Soils**, *International Journal of Scientific Engineering and Technology, v*ol. 3(5), pp.592-596, 2014.
4. Louis C. Murray, Jr. and Barbara-Ann G. Lewis, **Phosphogypsum waste anion removalby soil minerals**, *Journal of Environmental Engineering*, vol.111 (5), pp.681-698, 1985.
5. Madurwar. K.V, Dahale. P. P, Burile. A. N, **Comparative Study of Black Cotton Soil Stabilization with RBI Grade 81 and Sodium Silicate**, *International Journal of Innovative Research in Science, Engineering and Technology*, vol. 2(2), pp.493-499, 2013.
6. Sleiman M. Al-Zaidyeen and Arabi N. S. Al-Qadi (2015), **Effect of photogypsum as a waste material in soil stabilization of pavement layers**, *Jourdan journal of Civil Engineering*, vol. 9(1), pp.1-7, 2015.
7. Sujeet Kumar and Rakesh Kumar Dutta, **Unconfined compressive Strength of Bentonite-Lime-Phosphogypsum Mixture Reinforced with Sisal Fibers**, *Jordan Journal of Civil Engineering*, vol.8(3), pp. 239-250, *2014.*
8. Sujeet kumar, Rakesh Kumar Dutta, Bijayananda Mohanty, **Engineering properties of bentonite stabilized with lime and phosphogypsum**, *Slovak Journal of Civil Engineering*, vol. 22 (4), pp.35 – 44, 2014.
9. IS: 1498, **Classification and Identification of soils for engineering purposes**, *Bureau of Indian Standards*, 1970.
10. IS: 2720 part V , **Determination of Liquid & Plastic Limit,** *Bureau of Indian Standards*, 1985.
11. IS: 2720 part III, **Determination of Specific gravity of Fine grained soils**, *Bureau of Indian Standards*, 1980.
12. IS:2720 part-IV, **Grain Size analysis**, Bureau of Indian Standards, 1985.
13. IS: 4332 part-III (1967),**Test for determination of moisture content –dry density relation for stabilized soil mixtures,** *Bureau of Indian Standards*, 1967.
14. Mitchell, J.K., & Katti R.K., **Soil Improvement - State of the Art Report.** 10th ICSMFE, Stockholm, 4: pp.509-565, 1981.
15. Hausmann,M, **Engineering principles of Ground modification**, *Mc Graw-Hill Publications*, pp.56-57 Jan 1990.