Assessment of Black Cotton Soil Stabilization by Admixture

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Abstract
The experimental program was carried out on the black cotton soil to stabilize with the help of different admixture. The stabilization of black cotton soil is carried out with different methods earlier by many researchers. In the present study the admixture involves fly ash, marbel powder and MgCl in different proportions. The proportions of all these admixtures were varied from 15%, 30% to 45%. It was found from the experimental observations that the values of UCS, cohesion and dry density are maximum for the case of 30% addition of admixture in the soil. The free swell index reduces as the percentage of admixture is increases from 15% to 45%. Therefore the optimum percentage of addition of admixture is 30%.

Key Words: Fly ash, marbel powder, MgCl, admixture and strength of soil

1. Introduction

The relationship between the strength (dependent variable) with curing period, curing temperature and lime content (independent variable) was established. The unconfined compressive strength (UCS) test were conducted on the clayey soil which was first stabilized with lime contents with varying percentages of 3%, 5%, 7% and 9%. It was found that the relation between the strength and temperature was nearly linear for the content of lime if added less than the optimum content of lime. It was also found that the exponential relationship was established for optimum lime content[1].

In the study of FORTRAN programming for first order reliability, it was found that iron ore tailings content compacted with British standard light, specific gravity, sand & silt content is affected by the coefficient of variation. From the results it was recommended to use lime, cement in the mixture to be used in the pavement as a sub base material[2]. Extensive Lab based study was conducted on the black cotton soil stabilized with up to 8% lime and 10% iron ore tailings (IOT) compacted with British standard light. The recommendation to use only up to 8% lime or IOT for the treatment of black cotton soil to use it in the sub base of low volume roads[3].

Another study conducted to use cement kiln dust (CKD) to increase the durability property of black cotton soil as a subgrade in the pavement and modified with quarry fines. It was found that the soil if mixed with 8-16% CKD then it is suitable for the stable and durable pavement system[4]. Another experiment were conducted for the effect of curing time on the black cotton soil which is stabilized with varying percentages of 0-10% of CKD and 10% quarry fines. Results indicated that increase in UCS values if the content of CKD increases and also if the curing time for soil mixture increases[5].

The expansive soil treated with 0-20% fly ash and 0-3% fly ash lime, the different properties are studied like the free swell index, swelling pressure and UCS. With increase in the percentages of admixture the properties of expansive soil get decreases with addition of small quantity of lime to fly ash[6]. Pulverized coal bottom ash (PCBA) was tested on the cement stabilized black cotton soil. The results found that the use of 5% PCBA admixed with 8% cement stabilized BC soil, CBR and UCS values are increases[7].

The tests were performed on unstabilized BC soil and lime stabilized BC soil samples compacted to optimum for standard and modified proctor conditions. To reduce the plasticity of soil the lime treatment found to be effective and the resilient modulus increases with the increase in confining pressure[8]. The subgrade soil was also stabilized with the rice husk ash, sugarcane bagasse ash and cow dung ash. They were mixed by partial replacement of soil by weight 0% to 12.5%. There was considerable improvement in UCS, CBR and the volumetric change was under control with such stabilization technique[9].

By using the waste material like ground granulated blast furnace slag (GGBS) to make capable to take more loads from the footings. It was found that the OMC and MDD decreases as the percentage of GGBS added to the soil. Up to 20% increases in the addition of GGBS have resulted in increase in the strength for curing of 7 & 14 days[10]. Apart from above addition of admixtures in the soil the experiments were carried out on the stabilization of soil with the help of different kind of stabilization.
experiments consists of Deep Soil Densification for Shallow Foundations[11], study of Black Cotton Soil Characteristics with Cement Waste Dust and Lime[12] and Effect of different sand grading on strength properties of cement grout[13]. The experiments also consists of Experimental and numerical investigation of thermal properties of cement-based grouts used for vertical ground heat exchanger[14], Assessment of stabilization methods for soft soils by admixtures[15] and Insights into the biodegradation of weathered hydrocarbons in contaminated soils by bioaugmentation and nutrient stimulation[16].

2. Methodology

Materials used: The details of materials used for the stabilization of black cotton soil are as follows:

**Brick powder:** Burnt brick powder is a waste powder generated from the burning of bricks with the soil covered by surroundings.

**Marble Powder:** Marble is a highly valued rock known for its strength and ability to be polished as well as the resistance to weathering. Marble powder is obtained by crushing the marble.

**Fly Ash:** The class C type fly ash is used in the present study, this fly ash produced from the burning of sub-bituminous coal, which have some cementing properties.

**Magnesium Chloride (MgCl2):** In the present study the effect of MgCl2 solution on the characteristics of swelling potential of clay soil is investigated.

**Basic Black Cotton soil:** The locally available black cotton soil is used in the present study as the basic material.

**Properties of BC soil:** The properties of BC soil is mentioned in the below table no.1.

| Sr. No. | Property of Soil          | Test Performed          | Result       |
|---------|---------------------------|-------------------------|--------------|
| 1       | Specific Gravity (G)      | Pycnometer method       | 2.65         |
| 2       | Water Content (W.C.)      | Oven Drying method      | 6.85%        |
|         |                           | Torsion balance method  | 6%           |
| 3       | Grain Size Distribution   | Mechanical Sieve analysis | well graded D10=0.74, D30=1.65, D60=2.7, Cu=3.64, Cc=1.36 |
| 4       | Liquid limit              | Mechanical method       | 50.40%       |
|         | Plastic limit             | Plastic limit test      | 19.04%       |
| 5       | Free swell index          | Swell index test        | 56.66%       |

From the above table the compressive stress is obtained as in the table no.3:

**Standard Proctor Test:** The observation for standard proctor test for basic soil is as follows:

![Proctor compaction test for original soil](image)

From the above figure no.1 it was observed that the maximum dry density for the basic soil is 1.55 gm/cc and optimum moisture content is 23%.

**Unconfined Compressive Strength:** The observations for unconfined compressive strength (UCS) for basic soil are shown in the table no. 2.

| Sr. No. | Parameters                        | Value        |
|---------|-----------------------------------|--------------|
| 1       | Initial length of specimen        | 10.6         |
| 2       | Initial diameter of specimen      | 3.6          |
| 3       | Initial area of specimen          | 10.17        |
| 4       | Initial volume of specimen        | 107.89       |
| 5       | water content of soil             | 23%          |
| 6       | Mass of specimen                  | 178          |
| 7       | L.C. of deformation ring          | 0.01         |
| 8       | Proving ring constant             | 6.18         |

From the above values in the table the compressive stress is obtained as in the table no.3:
From the above table it was found that the UCS for basic soil sample is 2.34 N/cm².

**California Bearing Ration Value (CBR)**: The observation for CBR for basic soil sample is as shown in the table no.4:

| Sr. No. | Parameters                                      | values  |
|---------|-------------------------------------------------|---------|
| 1       | Optimum moisture content                        | 23%     |
| 2       | Wt of mould + compacted specimen (gm)           | 7148    |
| 3       | Wt of empty mould (gm)                         | 3900    |
| 4       | Wt of compacted specimen (gm)                   | 3248    |
| 5       | Volume of Specimen (gm)                        | 2250    |
| 6       | Bulk Density (gm/cc)                           | 1.45    |
| 7       | Dry Density (gm/cc)                            | 1.55    |
| 8       | Surcharged Weight used (kg)                     | 2.5     |
| 9       | L.C. for proving ring 1 division (kg)           | 0.618   |

From the above figure no.2 it is found that the basic soil + 30% fly ash + 1% MgCl showed good results in the terms of penetration as compared to other conditions.

The CBR for 2.5 mm penetration for basic soil + 30% fly ash + 1% MgCl is more as compared to other conditions as per the above figure no.3.
The CBR for 5 mm penetration for basic soil + 30% fly ash + 1% MgCl is more as compared to other conditions as per the above figure no.4.

![Figure 5](image.png)

**Fig. 5 :** Dry Density v/s percentage admixture added in the soil

As per the above figure no.5 the dry density for basic soil + marble powder is more as compared to other soil conditions while basic soil + brick dust have shown the lowest results. The values for dry density is maximum for the case of 30% addition of admixture while for 15% and 45% addition it is found to minimum.

![Figure 6](image.png)

**Fig. 6 :** UCS v/s percentage admixture added in the soil

As per the above figure no. 6, UCS for basic soil + fly ash + 1% MgCl found to be more than the other soil conditions as per the above graph. As the percentage of admixture is increased the value of UCS increases up to the 30% addition and thereafter it reduces even after adding further admixture.

![Figure 7](image.png)

**Fig. 7 :** Cohesion v/s percentage admixture added in the soil

Cohesion for basic soil + fly ash + 1% MgCl found to be more than the other soil conditions as per the above figure no.7. The values for cohesion is maximum for the case of 30% addition of admixture while for 15% and 45% addition it is found to minimum.

![Figure 8](image.png)

**Fig. 8 :** Free swell index v/s percentage admixture added in the soil

Free swell index for basic soil + marble powder found to be more than the other soil conditions as per the above figure no.8. The free swell index reduces as the percentage of admixture is increased from 15% to 45%.

### Conclusion

From the literature following points are concluded:

- Basic soil + 30% fly ash + 1% MgCl showed good results in the terms of penetration as compared to other conditions.
- The CBR for 2.5 mm & 5mm penetration for basic soil + 30% fly ash + 1% MgCl is more as compared to other conditions.
- The dry density for basic soil + marble powder is more as compared to other soil conditions while basic soil + brick dust have shown the lowest results.
- UCS & cohesion for basic soil + fly ash + 1% MgCl found to be more than the other soil conditions. The maximum values found for the 30% addition of admixtures in soil.
- Free swell index for basic soil + marble powder found to be more than the other soil conditions. As the percentage increases the free swell index reduces.

### References

[1] Amir Asad Nasrizar, K. Ilamparuthi, and M. Muttharam, "Quantitative Models for Strength of Lime Treated Expansive Soil," in GeoCongress 2012. [Online]. http://ascelibrary.org/doi/abs/10.1061/9780784412121.101
[2] K. J. Osinubi, A. O. Eberemu, P. Yohanna, and R. K. Etim, "Reliability Estimate of the Compaction Characteristics of Iron Ore Tailings Treated Tropical Black Clay as Road Pavement Sub-Base Material," in Geo-Chicago 2016. [Online]. http://ascelibrary.org/doi/abs/10.1061/9780784480144.085

[3] R. K. Etim, A. O. Eberemu, and K. J. Osinubi, "Stabilization of black cotton soil with lime and iron ore tailings admixture," Transportation Geotechnics, vol. 10, pp. 85-95, 2017. [Online]. http://www.sciencedirect.com/science/article/pii/S2214391217300119

[4] A. A. Amadi and A. S. Osu, "Effect of curing time on strength development in black cotton soil – Quarry fines composite stabilized with cement kiln dust (CKD)," Journal of King Saud University - Engineering Sciences, 2016. [Online]. http://www.sciencedirect.com/science/article/pii/S101836391630006X

[5] J. M. Kate, "Strength and Volume Change Behavior of Expansive Soils Treated with Fly Ash," in Innovations in Grouting and Soil Improvement. [Online]. http://ascelibrary.org/doi/abs/10.1061/04783%282014%2919

[6] Kolawole Juwonlo Osinubi, "Stabilisation of Tropical Black Clay with Cement and Pulverised Coal Bottom Ash Admixture," in Advances in Unsaturated Geotechnics. [Online]. http://ascelibrary.org/doi/abs/10.1061/04510%282017%2920

[7] K. H. Mamatha and S. V. Dinesh, "Resilient modulus of black cotton soil," International Journal of Pavement Research and Technology, vol. 10, pp. 171-184, 2017. [Online]. http://www.sciencedirect.com/science/article/pii/S199681416301316

[8] Anjani Kumar Yadav, Kumar Gaurav, Roop Kishor, and S. K. Suman, "Stabilization of alluvial soil for subgrade using rice husk ash, sugarcane bagasse ash and cow dung ash for rural roads," International Journal of Pavement Research and Technology, vol. 10, pp. 254-261, 2017. [Online]. http://www.sciencedirect.com/science/article/pii/S199681416301493

[9] Anil Kumar Sharma and P. V. Sivapullaiah, "Ground granulated blast furnace slag amended fly ash as an expansive soil stabilizer," Soils and Foundations, vol. 56, pp. 205-212, 2016. [Online]. http://www.sciencedirect.com/science/article/pii/S0038080616000251

[10] Ramanuja Chari Kannan, "Deep Soil Densification for Shallow Foundations," in Advances in Shallow Foundations. [Online]. http://ascelibrary.org/doi/abs/10.1061/40915%282017%29291

[11] J. B. Oza and P. J. Gundaliya, "Study of Black Cotton Soil Characteristics with Cement Waste Dust and Lime," Procedia Engineering, vol. 51, pp. 110-118, 2013, Chemical, Civil and Mechanical Engineering Tracks of 3rd Nirma University International Conference on Engineering (NUiCONE 2012). [Online]. http://www.sciencedirect.com/science/article/pii/S1877705813000180

[12] Siong Kang Lim, Cher Siang Tan, Kah Pin Chen, Min Lee Lee, and Wah Peng Lee, "Effect of different sand grading on strength properties of cement grout," Construction and Building Materials, vol. 38, pp. 348-355, 2013, 25th Anniversary Session for ACI 228 – Building on the Past for the Future of NDT of Concrete. [Online]. http://www.sciencedirect.com/science/article/pii/S0950061812006228

[13] Daehoon Kim, Gyoungman Kim, Donghui Kim, and Hwanjo Baek, "Experimental and numerical investigation of thermal properties of cement-based grouts used for vertical ground heat exchanger," Renewable Energy, vol. 112, pp. 260-267, 2017. [Online]. http://www.sciencedirect.com/science/article/pii/S0960148117304305

[14] S. Kazemian and B. B. K. Huat, "Assessment of stabilization methods for soft soils by admixtures," in 2010 International Conference on Science and Social Research (CSSR 2010), Dec. 2010, pp. 118-121.

[15] Ying Jiang et al., "Insights into the biodegradation of weathered hydrocarbons in contaminated soils by bioaugmentation and nutrient stimulation," Chemosphere, vol. 161, pp. 300-307, 2016. [Online]. http://www.sciencedirect.com/science/article/pii/S0045653516309274