International Journal of New Technology and Research (IJNTR)
ISSN:2454-4116, Volume-1, Issue-3, July 2015 Pages 42-45

Augmenting the Properties of Black Cotton Soil Using Additives

Manjularani.P, Channabasavaraj.W, MdKhajaMoniuddin

***Abstract*— Black cotton soil is very susceptible to detrimental volume changes, with changes in moisture. This behavior of soil is attributed to the presence of mineral Montmorillonite which has expanding lattice; Black cotton soils because of their specific physical & chemical make are subjected to volume changes. In many countries including India, these soils are so extensive that alteration of highway route to avoid the material is virtually impossible. Various remedial measures like soil replacement, prewetting, moisture control, lime stabilization etc have been practiced with varied degree of success. Extensive research is going on to find the solutions to black cotton soils. In the present work experimentation is carried out to investigate efficacy of lime, fly ash, Alkalis and other Additives in improving the properties of black cotton soil**

***Index Terms*— Fly ash, Lime, Alkalis, Sodium Chloride, Magnesium Chloride, O.M.C, M.D.D..**

I. INTRODUCTION

Compaction is a mechanical process in which the densification is achieved through the expulsion of air voids at almost constant water content of the soil mass. While the compaction is relatively an instantaneous process, consolidation is a time dependent process. For the majority of the activities adopted in the field to achieve soil compaction, the major input is the results of laboratory compaction tests-standard or modified proctor or mini compaction tests. The process of compaction, particularly of fine grained soils seem to be a complex one as the soil may be composed of both active and relatively inactive clay minerals.

The results of compaction tests are normally expressed in the form of dry density v/s water content relationship. The two important compaction characteristics are optimum moisture content (OMC) and maximum dry density (MDD). The important factors which affect these characteristics are the compactive effort and the type of soil. With increasing compactive effort, the maximum dry density increases and the optimum moisture content decreases (Lambe, 1993). Although the fundamentals of compaction are not completely understood, it is known that water plays an important part, especially in the fine-grained soils.

The following are the important effects of compaction:

1. Compaction increases the dry density of soil, thus increasing its shear strength and bearing capacity through an increase in frictional characteristics
2. Compaction decreases the tendency for settlement of soil and
3. Compaction brings about a low permeability of the soil.
4. Reduction in shrinkage
5. Reduction of subsidence from the reduced void ratio

In the present investigation, effect of alkalis on compaction characteristics of lime treated black cotton soil, fly ash mixture and other additives have been presented.

II. RESULTS AND DISCUSSIONS

The effect of alkalis on lime treated black cotton soil and fly ash mixture on the compaction characteristics have been studied. The results and discussions are presented in the following sections.

A. Effect of Fly ash

Compaction is the process of increasing the density of the soil by packing the particles closer together with reduction in the volume of air. Densification of soil improves their engineering properties. The dry density of a given soil after compaction depends on (i) water content, (ii) compactive effort, (iii) soil type and (iv) admixtures (Bowles, 1984).The dry density and water content depends on the amount of silica and free lime content in the fly ash.

The optimization of fly ash have been done by adding various percentages of fly ash to the soils and based on the various test results, it was found that 50% Muddanur fly ash is optimum for expansive Black cotton soil. The effect of fly ash on expansive montmorillonitic Black cotton soil has been studied on the compaction characteristics The maximum dry density of black cotton soil and fly ash alone were found to be 14.74kN/m^3 and 15.34kN/m^3 respectively
with optimum moisture content of 31.00% and 20.30%. On addition of various percentages of fly ash to the black cotton soil the maximum dry density increases to 16.88kN/m^3 with decrease in optimum moisture content is 18.20% upon addition of 50% fly ash. Beyond 50% addition of fly ash the maximum dry density decreases with increase in optimum moisture content as shown in figure 1 The addition of fly ash to BC soil decreases the optimum moisture content and increases the maximum dry density (Leonards and Bailey, 1982). This may be due to decrease in repulsive pressure of soil, which resists compactive effort, consequently soil particles become closer. The behaviour of black cotton soil is controlled by diffused double layer. The addition of fly ash in small percentage resulted in decrease of repulsive pressure of

Manjularani.P, Civil Engineering Department, Don Bosco Institute of Technology/ Bangalore/ India
Channabasavaraj.W, Department of Civil Engineering, Don Bosco Institute of Technology (Affilated to VTU Belagavi), Bangalore, India
MdKhajaMoniuddin, Civil Engineering Department, BheemannaKhandreInstitute of Technology/ Bhalki/ India.

soil particles. This in turn reduces the resistance to compactive effort and the mix gets compacted to relatively higher densities (Udayashankar and Puranik, 2012).

The optimum moisture content has reduced from 31.00% to 18.20% upto 50% addition of fly ash. With decrease in the repulsive pressure, due to addition of fly ash with lower water absorption capacity, the OMC decreases. Addition of non-plastic fly ash particles to the expansive clay the water content required for reorientation of the particle will be less hence optimum moisture content reduces. Increase the repulsive forces of soil particles, thereby increasing the resistance to compactive effort and hence the density of mix starts decreasing (Udayashankar and Puranik)

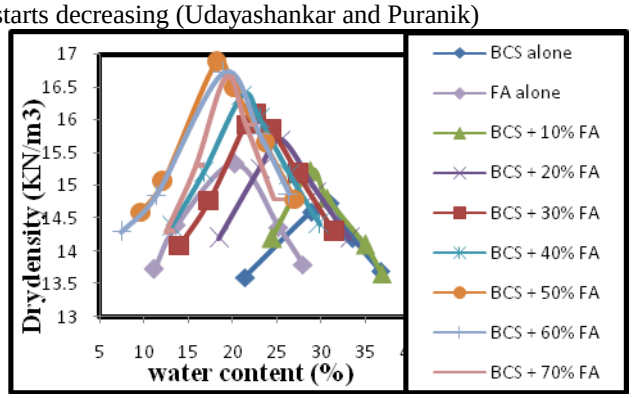


Figure 1: Variation of dry density-water content relationship of Black cotton soil treated with various percentage of Fly ash

B. Effect of Lime

The tests were conducted on optimum percentage of fly ash and black cotton soil mixture with 1% to 5% of lime content. The maximum dry density and optimum moisture content of optimum fly ash and black cotton soil mixture is 16.88kN/m^3 and 18.20% respectively. The optimization of lime have been done by adding various percentages of lime to the Black cotton soil and fly ash mixture based on the various test results, it was found that 3% lime is optimum for expansive Black cotton soil. On addition of 1% to 5% lime content, the maximum dry density increases upto 3% of lime with decrease in optimum moisture content as shown in figure 2.

Thus, addition of 3% lime results in the increase in maximum dry density beyond which the dry density decreases with increase in optimum moisture content. This is due to the increased flocculation and agglomeration of soil particles having large void spaces occupied by lime leading to a corresponding decrease in maximum dry density (Ola, 1977 and Lees et al, 1982) with increase in availability of lime content. This would increase the repulsive forces of soil particles, thereby increasing the resistance to compactive effort.

The increase in OMC of expansive clays treated with lime may be caused by flocculation so that when compacted the soil each have an increased volume of voids compared with untreated soil, in addition the increase in hydroxyl ions liberated by lime, increases the affinity of the surfaces of clay particles for water (Bell, 1987). The increase in optimum moisture content is due to the increasing demand for water by various cations and the clay mineral particles to undergo hydration reaction. The increase in optimum moisture content is probably a consequence of the additional water held within the flocculent soil structure resulting from lime interaction and exceeding water absorption by lime as a result of its lower specific gravity (Muntohar and Hantoro, 2000).

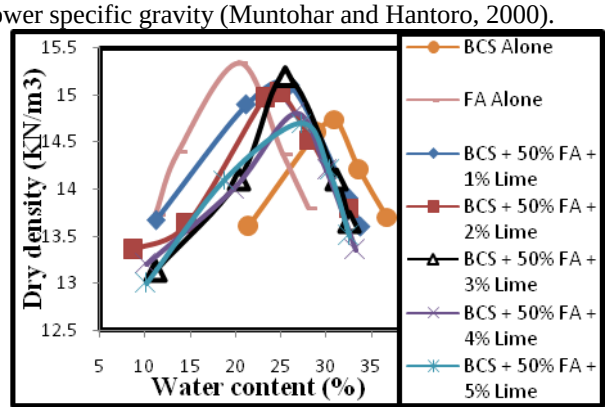


Figure 2: Variation of dry density-water content relationship of Black cotton soil and optimum Fly ash mixture treated with various percentages of Lime

C. Effect of Alkalis

1. Effect of Calcium Carbonate

The optimization of alkalis has been done by adding various percentages of alkalis to the lime treated Black cotton soil and fly ash mixture based on the various test results, it was found that 10% Calcium carbonate is optimum for expansive Black cotton soil.

The maximum dry density and optimum moisture content of Black Cotton soil is 14.74kN/m^3 and 31.00% respectively. On addition of various percentages of Calcium Carbonate, maximum dry density increases and optimum moisture content is decreases upto 10% which is an optimum percentage for Calcium Carbonate. Beyond 10%, maximum dry density decreases as shown in figure 4This is due to flocculation between soil and calcium carbonate particles (Venkataraja Mohan 2011). The maximum increase in dry density is found as 14.90kN/m^3. This may be due to the density and Specific Gravity of Calcium Carbonate used is higher than that of BC soil and decrease in moisture content is attributed to reduction in diffused double layer by cation exchange.

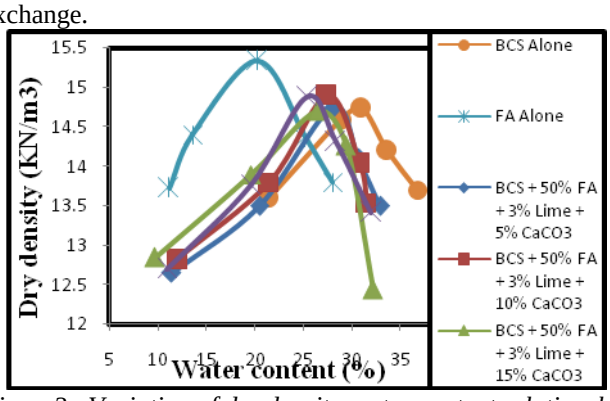


Figure3 : Variation of dry density-water content relationship of Black cotton soil, optimum Fly ash and lime mixture treated with various percentages of Calcium Carbonate

2. Effect of Magnesium Carbonate

Based on the various test results, it was found that 15% Magnesium carbonate is optimum for expansive Black cotton soil. On addition of various percentages of Magnesium Carbonate, maximum dry density increases and optimum moisture content is increases upto 15% which is an optimum percentage for Calcium Carbonate. Beyond 15%, maximum dry density decreases and optimum moisture increases as shown Figure 4.

The maximum dry density and optimum moisture content of Black Cotton soil is 14.74kN/m^3 and 31.00% respectively, Maximum dry density decreases to 12.16kN/m^3 and optimum moisture content is increases to 40.20% on 15% addition of Magnesium Carbonate. This is due to flocculation and hydration between soil and Magnesium carbonate particles (Venkataraja Mohan 2011). This may be due to the light weight of Magnesium Carbonate and more water holding capacity of the rearranged particles.

3. Effect of Sodium Salts

The maximum dry density and optimum moisture content of Black Cotton soil is 14.74kN/m^3 and 31.00% respectively. The maximum dry density
of lime treated Black cotton soil and fly ash mixture treated with Calcium carbonate and Magnesium carbonate is 14.90kN/m^3 and 12.16kN/m^3 respectively.

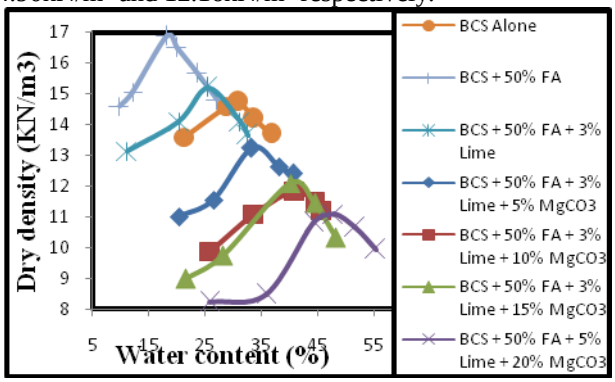


Figure 4: Variation of dry density-water content relationship of Black cotton soil, optimum Fly ash and lime mixture treated with various percentages of Magnesium Carbonate

Addition of 1% sodium salts (NaOH and NaCl) to Black cotton soil treated with optimum percentage of fly ash, lime and Calcium Carbonatethe maximum dry densities were observed to be 14.92kN/m^3 and 14.68kN/m^3 and optimum moisture content were 25.4% and 25.7% with NaOH and NaCl respectively. Similarly with Magnesium Carbonatethe maximum dry densities were observed to be 12.45kN/m^3 and 12.2kN/m^3 and optimum moisture content were 37.0% and 38.20% with NaOH and NaCl respectively as shown figure 5 The increase in optimum moisture content is as a result of increasing demand for water by various cations and the clay mineral particles to undergo hydration reaction (Moses 2008, Osinubi 1997). This may be due to the formation of more gelatinous compounds, which can retain high water content as there was no much time elapsed after mixing sodium salts.

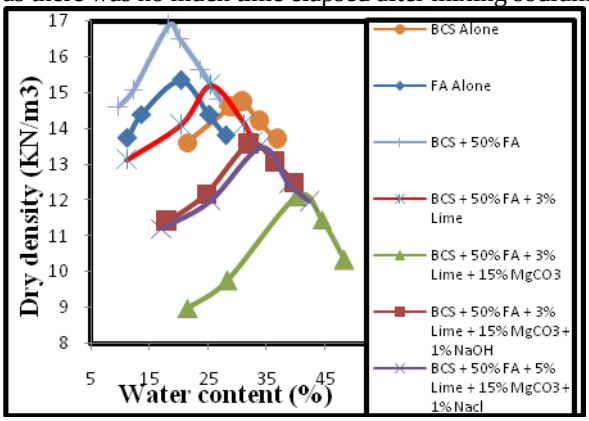


Figure 5: Variation of dry density-water content relationship of Black cotton soil, optimum Fly ash, lime and Alkalis mixture (a) Calcium carbonate (b)Magnesium carbonate treated with 1% Sodium salts

III. CONCLUSION

1. Addition of various percentages of fly ash to black cotton soil, the maximum dry density increases with decreasing in optimum moisture content upto 50% fly ash addition, thereafter maximum dry density decreases with increase in optimum moisture content due to decrease in repulsive pressure of soil, which resists compactive effort, consequently soil particles become closer with lower water absorption capacity.

2. Addition of 1 to 5% lime to optimum fly ash treated black cotton soil, the maximum dry density increases upto 3% lime addition, thereafter maximum dry density decreases with increase in optimum moisture content due to the increasing demand for water by various cations and the clay mineral particles to undergo hydration reaction. This is due to the increased flocculation with increase in availability of lime content. This would increase the repulsive forces of soil particles, thereby increasing the resistance to compactive effort.

3. On addition of various percentages of Calcium Carbonate to the optimum mixture maximum dry density increases and optimum moisture content is decreases upto 10% which is an optimum percentage for Calcium Carbonate, beyond 10%, maximum dry density decreases with increase in optimum moisture content. This is due to the density and Specific Gravity of Calcium Carbonate used is higher than that of BC soil and decrease in moisture content is attributed to reduction in diffused double layer by cation exchange.

4. On addition of various percentages of Magnesium Carbonate to the optimum mixture maximum dry density increases and optimum moisture content is decreases upto 15% which is an optimum percentage for Magnesium Carbonate, beyond 15%, maximum dry density decreases with increase in optimum moisture content. Maximum dry density achieved is less and optimum moisture content is more than that of Black cotton soil alone. This is due to the light weight of Magnesium Carbonate and more water holding capacity of the rearranged particles.

5. Addition of 1% sodium salts to Black cotton soil treated with optimum percentage of fly ash, lime and alkalis the maximum dry density increases with decrease in optimum moisture content. This may be due to the formation of more gelatinous compounds.

REFERENCES

[1] Mir, (2004) - The effect of Fly ash on geotechnical Properties of soils

[2] Phanikumar and Sharma, (2004) - The effect of fly ash on engineering properties of expansive soil through an experimental program

[3] Shukla and Kukalyekar, (2005) - The effects of compaction energy on the Geotechnical properties of Fly

[4] Bell, (1987) - Enhancement of the properties of clayey soils by addition of cement or lime.

[5] Hussain and Dash, (2009) - Influence of lime on compaction behavior of soils

[6] Evans and Bell, (1978) - The phosphoric stabilization for insituloessial soils of Banks Peninsula

[7] H.N. Ramesh et al., (2002) - Effect of muddanaur Fly ash on Index and compaction behavior of Expansive soil

[8] NarasimhaRao et al., (2012) - Efficiency of sodium carbonate and

calcium carbonate in stabilizing a black cotton soil.

[9] Dr.B.C.Punmia et al., "soil mechanics and foundation", 16th edition, March 2005 pp849-856.

[10] SubbaRao K.S. 2000 Swell-shrink behavior of expansive soils-Geotechnical challenges. *Indian Geotechnical Journal, 30, 1-69.*

[11] Katti R.K. 1979. Search for solutions for problems in black cotton soils. *Indian Geotechnical Journal, 9, 1-80.*

[12] ErdalCokca (2001) "Use Of Class C Fly Ashes for the Stabilization – of an Expansive Soil Journal of Geotechnical and Geo-environmental Engineering Vol. 127, July, pp. 568-573

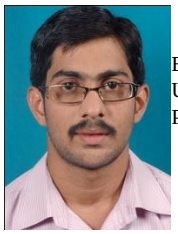
[13] Foundation Analysis and Design by Bowles

[14] Soil Engineering Testing, Design and Remediation – Dr.FaHua Chen, P.E.

Manjularani.P

Education:
UG: BE in Civil Engineering
PG: Master of Engineering in Earthquake Engineering

1. Published paper in the proceedings on "Soil Nail Wall for deep excavation and its performance under seismic condition", in "Indian Geotechnical conference (IGC)-2014", December 18-20 Kakinada, India. page no- 843 to 849.



Channabasavaraj.W

Education
UG: BE in Civil Engineering
PG: Master of Engg in Geotechnical Engg

- Published an international journal paper in "Applied Clay Science" (2014) titled: Simulation of fabric in sedimented clays, (article in press).

- An international journal paper has been submitted to "Engineering Geology", titled: Characterization of samples from Lonar Crater, India, (Under review).

- Presented a technical paper in an international conference (Seventh international conference on case history in Geotechnical Engineering) at university of Illinois, Chicago, USA. Title: "Influence of Relative Position of the Tunnels, A Numerical Study on Twin Tunnels", by varied soil parameters and design conditions.

- Presented a technical paper in International level Conference (Indian Geotechnical Conference) at IIT Delhi (2012). Title: Influence of Relative Position of the Tunnels - Numerical Analysis on Interaction between Twin Tunnels.

- Presented a technical paper in a International level Conference (Indian Geotechnical Conference) at JNTU Kakinada (2014). Title: Characterization of Dredged Sediments.

MdKhajaMoniuddin

Education
UG: BE in Civil Engineering
PG: Master of Engg in Geotechnical Engg

Pursuing Ph.D,

1. Presented paper on "Disaster Management" in for "International Conference on Communication,Computation,Control and Nanotechnology (ICN2011)" at R.E.C,Bhalki.

2. Presented paper on "Earthquake analysis of 2D RC frames with different aspect ratio for Masonry infill and Monolithic panel", at "International Conference on Recent Innovative in Civil Engineering (IC-RICE 2013)", P.D.A, Gulbarga.

3.Published paper on "Finite Element Analysis of Soil Bearing Capacity Using PLAXIS", in "International Journal for Scientific Research and Development (IJRSD)" e-ISSN-2321 0613.

1. Reviewer Board member for "International Journal of Advanced Research in Computer Science & Technology [IJARCST]". e-ISSN 2347-8446; p-ISSN 2347-9817.

2. Membership in Technical bodies of "American society for Civil Engineer (ASCE), International Association of Engineers (IAENG), CSTA.

3. Member for National Information Centre of Earthquake Engineering [NICEE], IIT Kanpur India, Membership Number: 14SY0904.

4. Reviewer Board member for "International Journal of Research in Engineering & Technology [IJRET]". e-ISSN 2319-1163; p-ISSN 2321-7308.