Utilization of GGBS and Lime to Improve the Compaction and Unconfined Strength Properties of Marine Clay

Ranga Swamy[1], Purushotham G Sarvade[2], Deepak Nayak[3]

PG student[1], Associate Professor[2], PG student[3]
Department of Civil Engineering,
Manipal Institute of Technology, Manipal University, Manipal, Udupi, Karnataka.
sranga34@gmail.com

ABSTRACT—Marine deposits are usually found along the seacoast. Marine clay expands in the presence of water and shrinks when it dries. When a structure is built on such a type of soil, the structure may experience severe stresses. In the present study an effort is made to improve the geotechnical properties of marine clay using ground granulated blast furnace slag (GGBS) and Lime. Marine clay is replaced by 20% GGBS by weight of soil and Lime is added (0%, 4%, 8%, 12%, 16% and 20%) by dry weight of soil. A detailed laboratory study is carried out to study the compaction and unconfined strength properties before and after stabilization with GGBS and Lime. It has been found from Unconfined compressive strength (UCS) test, 20% GGBS replacement and 16% Lime addition to dry weight of soil gave (650kPa) optimum results.

Keywords—Ground granulated blast furnace slag, Lime, Marine clay.

1. INTRODUCTION

Marine deposits are usually found along the seacoast. Marine clay expands in the presence of water and shrinks when it dries. When a structure is built on such a type of soil, the structure may experience severe stresses. There are different types of ground improvement techniques through which soil can stabilized. Out of which physical and chemical method of stabilization proves to be economical. The different types of admixtures used in the above method are lime, cement, fly ash, ground granulated blast furnace slag (GGBS) etc. Many research work have been carried out using cement and Lime as an admixture. Cement and Lime cause severe environmental issues during its production. One tonne of CO_2 is produced during the production of one tonne of cement. Now a day's use of cement for soil stabilization is reduced because of increasing cost of cement and its CO_2 emission. These days focus is shifted to make use of industrial waste in the stabilization of soil. Due to rapid urbanization, steel is used as one of the major material in construction. GGBS is a bi-product of the steel manufacturing unit.

GGBS is obtained by quenching molten iron blast furnace slag immediately in water or stream, to produce a glassy granular products then it is dried and ground to a fine powder. It has good binding property and hence it is widely used in cement and concrete. Using these type of waste reduces environmental issues as well as saves cost of the project.

The main objective of the paper is to study the geotechnical properties of marine clay using GGBS and Lime. It has been found that addition of GGBS improved the strength of soft soil in soaked and unsoaked conditions [15]. By addition of fly ash and GGBS to soil specimen, California Bearing Ratio has been improved [17]. Increase in Lime content decreased the compressibility of marine clay [4]. Permeability characteristics of marine clay have been increased by increase of Limepercentages [3]. The strength of marine clay drastically increased by increase of Lime content [5]. The Physical-chemical properties of marine clay increased due to Lime and cement content [6]. Addition of 15% sawdust and 4% Lime to marine clay gave best results [14]. The strength of black cotton soil enormously increased by the expansion of fly ash, GGBS and Lime [1]. Initial tangent modulus of expansive soil increased by increase in GGBS content [2]. The consistency limits of black cotton soil improved by the addition of GGBS [16]. Marine clay stabilized with 20% GGBS gave best results for compaction and unconfined strength properties of marine clay [18]. Hence to study the effect of GGBS and Lime on Marine clay, laboratory compaction and strength tests were carried out to study stabilize GGBS-Lime. Hence research work presented on this paper is mainly concentrated on the stabilization of Marine clay soil with GGBS and Lime.

2. MATERIALS USED

2.1 Soil

Marine clay was collected from Kaup of Udupi District, Karnataka (India). A series of tests were conducted in the

laboratory according to IS Specifications to get the Geotechnical properties of soil. For the investigation, soil is oven dried and sieved through 425μ before its use.

2.2 GGBS

The Ground granulated blast furnace slag used for stabilization was obtained from RMC Ready Mix India plant near Manipal of Udupi District. The physical properties of marine clay and GGBS are determined as per IS specifications and presented in Table 1. Particle size distribution of marine clay and GGBS used in this study is specified in Table 2.

Table 1: Physical Properties of Marine Clay

Properties	***Marine clay***	***GGBS***
Specific Gravity	2.33	2.82
Liquid Limit (%)	22.58	29.37
Plastic Limit (%)	12.44	NP
Shrinkage Limit (%)	8.51	30.45
Plasticity Index (%)	10.14	NP
Free Swell Index(cm^3/g)	9.09	0
OMC (%)	14.96	22.63
MDD (kN/m^3)	15.79	14.72

Table 2: Particle size Distribution

Constituent	***Materials***	
	Marine clay	***GGBS***
Gravel Size	34.20	0.0
Sand Size	65.00	97.67
Silt and Clay Size	0.80	2.33
Soil Classification	SP	-

3. METHODOLOGY

3.1 Compaction and Unconfined strength properties(UCS)

Strength, compressibility and permeability are controlled by unit weight parameter. Soil samples for the test were prepared by 20% replacement with GGBS [18] and addition of different percentages of lime (0%, 4%, 8%, 12%, 16% and 20%) by dry weight of soil and then thoroughly mixed to maintain the homogeneity.

Soil samples are prepared based on results obtained from compaction test (MDD and OMC). For UCS test 38mm diameter and 76mm height samples were prepared and tested as per IS specifications.

3.2 Experimental investigation

Experimental investigation is carried out on soil samples unstabilized and stabilized with GGBS (20%) and Lime (0%, 4%, 8%, 12%, 16% and 20%) by dry weight of soil. The soil samples were tested to study the compaction characteristics as per IS 2720 part 7(1980) and unconfined compression strength as per IS 2720 part 10(1973).

4. RESULTS AND DISCUSSIONS

4.1 Compaction characteristics

Fig. 1 and Fig. 2 shows the variation of maximum dry density with the increase in the percentage of lime and Fig. 3 shows the variation of optimum moisture content with the increase in percentage of lime. Table 3 summarizes the optimum moisture content and maximum dry density of different percentages of lime. Addition of any admixture to the soil should increase MDD and decrease OMC. Addition of GGBS to soft soil, as OMC decreases MDD increases [15]. But in our study it is found that as the percentage of admixture (20% GGBS + 0 to 20% Lime) increased, MDD decreased with increase in OMC.This decrease in MDD is due to utilization of compactive effort in breaking the bond between Lime and soil+GGBS.

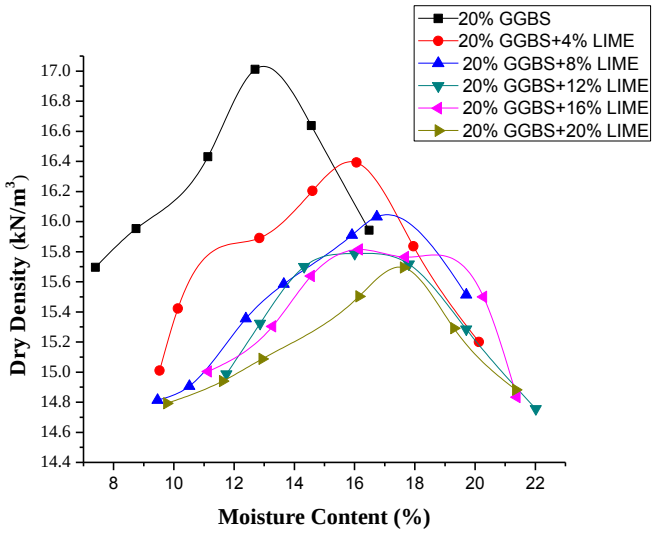

Figure 1: Compaction curves of Marine clay with 20% GGBS+Lime

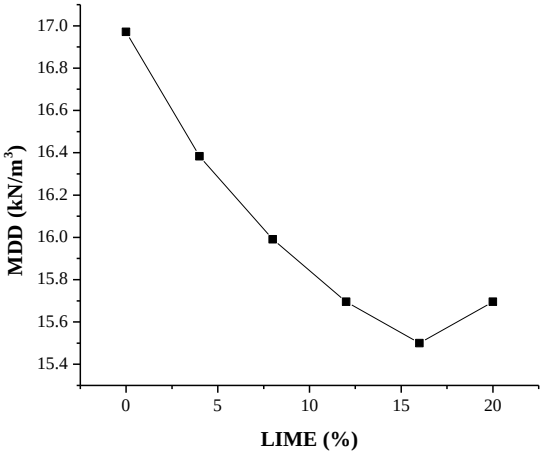

Figure 2: Variation of MDD with 20% GGBS+Lime content

Table 3: Summary of Lime+20% GGBS Soil Mixtures (OMC and MDD)

Constituent	***Dry Density(γ_d) kN/m^3***	***OMC (%)***
20% GGBS+0% Lime	16.97	12.7
20% GGBS+4% Lime	16.38	16.3
20% GGBS+8% Lime	15.99	16.4
20% GGBS+12% Lime	15.70	18.1
20% GGBS+16% Lime	15.50	20.3
20% GGBS+20% Lime	15.70	17.6

4.2 *Unconfined Compression Strength (UCS)*

The variation of UCS of soil+GGBS with different percentages of lime content is shown in Fig. 4. It can be seen from the figure that the strength gradually increases upto 4% lime addition and there is a decreasing trend for 8% addition. Further addition of Lime increased UCS of soil sample.

The strength increased from 82kPa to 650kPa with addition of 16% Lime. Increase in strength is due to cementation by pozzolanic compounds produced.

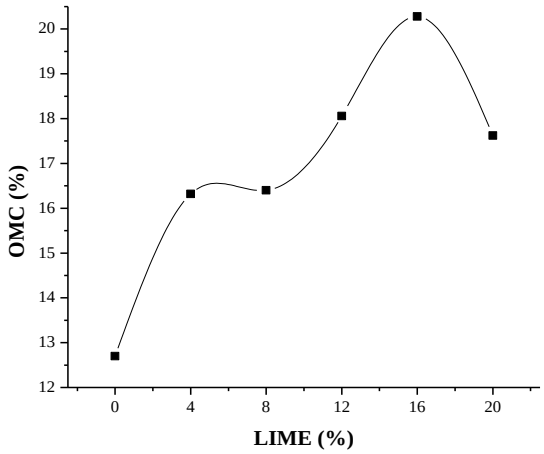

Figure 3: Variation of OMC with 20% GGBS+Lime content

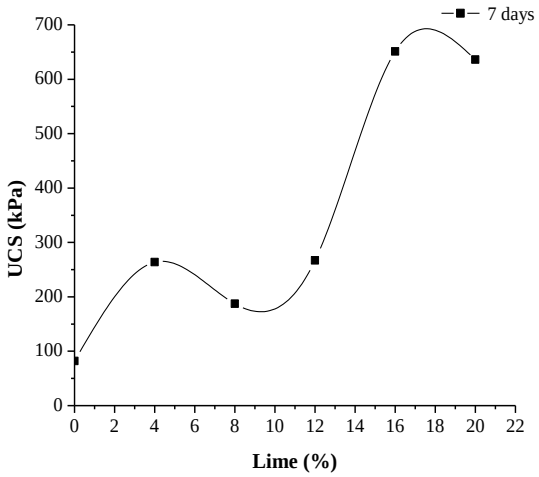

Figure 4:UCS curves of Marine clay with 20% GGBS+Lime content after curing period of 7Days

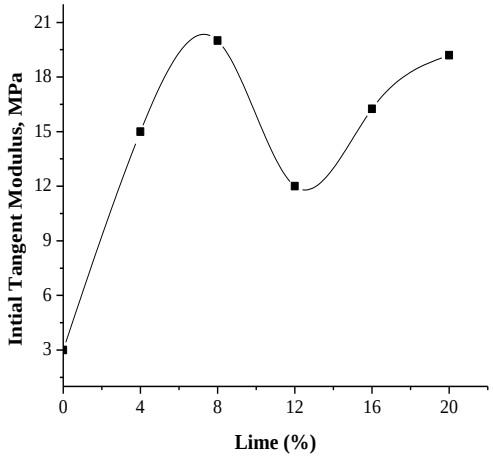

Figure 5: Variation of initial tangent modulus with 20% GGBS and Lime content after curing period of 7Days

4.3 *Effect of GGBS content on initial tangent modulus of marine clay- GGBS specimens confined Compression Strength (UCS)*

The stiffness of marine clay-Lime and GGBS specimens was represented by initial tangent modulus calculated from the stress versus strain response of soil-GGBS+Lime specimens. The effect of change in different percentages of Lime on the tangent modulus of specimens tested after 7 days is shown in Fig. 5.

It is clear from the above Fig.5, the initial tangent modulus of marine clay-Lime and GGBS specimen increased with the increase in Lime content up to 8%. Beyond this Lime content a negligible decrease in the initial tangent modulus value is observed. Initial tangent modulus increases upto 20% replacement GGBS and 8% addition of lime and decreasing and increasing trend was found.

5. CONCLUSION

The following are the observations made from the present experimental investigations:

1. There is decrease in maximum dry density up to 16% lime addition.
2. There is increase in the Optimum moisture content up to 16%.
3. Unconfined compressive strength of Soil-Lime and GGBS specimen increased with the increase in Lime content upto 16% and thereafter decreasing trend was found.
4. Initial tangent modulus found to increase up to 8% addition of lime content.

From the experimental investigations it has been found that 20% replacement of GGBS with addition of 16% lime to the marine clay gives optimum results.

6. ACKNOWLEDGMENT

The authors would like to express their sincere thanks to The Director and H.O.D, Civil engineering Department, Manipal Institute of Technology, Manipal for providing the necessary facilities required for the present study. The authors also like to thank A. G. Associates, Udupi, for helping to procure soil samples.

7. REFERENCES

1. Anil Kumar Sharma, P.V.Sivapullaiah, "Soil stabilization with waste materials based binders", Proceedings of Indian Geotechnical conference December 15-17, 2011.
2. Anil Kumar Sharma and P.V.Sivapullaiah, "Improvement of strength of expansive soils with waste granulated blast furnace slag", Geo-congress, PP.3920-3928, 2012.
3. G.Rajasekaran, S.Narasimha Rao, "Permeability characteristics of Lime treated marine clay", Ocean Engineering, Volume No.29, PP.113-127, 2002.
4. G.Rajasekaran. S.Narasimha Rao, "Compressibility behavior of Lime treated marine clay", Ocean Engineering, Volume No.29, PP. 545-559, 2002.
5. G.Rakashekaran and S.Narasimha Rao, "Falling cone method to measure the strength of marine clays", Ocean Engineering, Volume No.31, PP.1915-1927, 2004.
6. G. Rajasekaran, "Sulfate Attack and Ettringite formation in the Lime and cement stabilized marine clays", Ocean Engineering, Volume No. 32, PP. 1133-1159, 2005.
7. IS: 2720 –Part-3-1980, "Determination of Specific gravity".
8. IS: 2720 -Part 40-1977, "Determination of free swell index of soil".
9. IS:2720–Part-10-1973,"Determination of unconfined compressive strength test".
10. IS: 2720 –Part-7-1980, "Determination of water content-dry density relation using light compaction".
11. IS: 2720 –Part-4-1985, "Grain Size Analysis".
12. IS:2720-Part-5-1985, "Determination of Liquid and plastic limits".
13. IS:2720-Part-6-1972, "Determination of Shrinkage factors".
14. Koteswara Rao M.Anusha, P.R.T. Pranav, G.Venkatesh, "A Laboratory Study On The Stabilization Of Marine Clay Using Saw Dust And Lime", International Journal Of Engineering Science & Advanced Technology-Volume No.2, Issue No.4, PP. 851 – 862, 2012.
15. Laxikant Yadu and Dr. R.K.Tripathi, "Effect of GGBS in the Engineering behavior of stabilized soft soil", Procedia Engineering 5, PP.125-131, 2013
16. Noorina Tarannum and R.K.Yadav, "Influence of Blast furnace slag on the consistency limits of black cotton soil", International journal of scientific and Engineering research -Volume No. 4, Issue No. 4, PP. 456-458, 2013.
17. Oormila.T.R. and T.V.Preethi, "Effect of stabilization using fly ash and GGBS in soil characteristics", International Journal gineering Trends and Technology – Volume No.11 No.6, PP.284-289, 2014.

18. Puushotham G Sarvade, Ranga swamy and Deepak Nayak, "Utilization of GGBS to improve compaction and unconfined compression strength properties of marine clay", Proceedings of International conference on Advances in Civil Engineering Materials and Processes, CIT coimbotore, Jan 7th, 8th and 9th , 2015.
19. Gopal Ranjan and A S R Rao, Basic and Applied Soil Mechanics, 2nd edition, New Age Publications (P) Limited, 2013.
20. Dr.P.Purushothama Raj, Ground improvement techniques, 1st edition, University science press, 2013.