Improvement of Marine Clay using Chemical Physical Combined Method

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***Abstract*— Developing works in coastal areas involve dredging works for construction of structures.The objective of this project is to improve dredged marine sediments with lime and fly ash incorporated with geobag for potential reuse as wave breakers. Dredging work is usually necessary for coastal construction work and this material should be removed in an economical way. Marine clay samples used in the study were dredged in southern coast of India. Geotechnical tests were conducted to determine the properties of the natural clay samples. The optimum lime and fly ash content by weight was determined as 6 % and 15% respectively. Unconfined compressive strength and split tensile strength tests were conducted to determine the shear strength and tensile strength of marine clay. The unconfined compressive strength and tensile strength values with the use of wetted geobag are much higher than that without it. Also the compressive strength and tensile strength values increased with curing. Maximum strength is achieved at 28 days of curing. Thus chemical stabilization using lime and fly ash together incorporated with geobag can be used for the improvement and drying of the marine clay soil. The original unconfined compressive strength and tensile strength values of the dredging soil were close to zero because of high water content. One month after improvement by chemical physical combined method, the strength values increased and the test results demonstrated that this type of marine clay can be improved with chemical physical combined method.**

Keywords—Marine Clay, Lime, Fly Ash, Geobag, Unconfined Compressive Strength Test, Split Tensile Strength Test

I. INTRODUCTION

In the modernization effort of the country, development of the coastal region is inevitable for a country with a rich maritime history like India. The developing works in coastal areas involve dredging works for construction of structures, such as ports, waterways, and breakwaters, land reclamation, and widening sections of river or sea to facilitate economic activities and to erect coastal protection systems. Perhaps the less well-known but equally important purpose of dredging is the maintenance of port facilities. Dredging works at sea may be defined as the transfer process and removal of soil at the bottom of the sea to increase the sea depth, with the main purpose of keeping harbours and waterways accessible, where the area of dredging activities may consist of ponds and lakes, rivers and river mouth, port and harbours, and bays and inlets.Apparently, dredging is necessary for the development of coastal area, especially in solving sedimentation problems caused by natural processes or manmade activities. It is also crucial in providing appropriate water depths and turnings at waterways to maintain the viability of a maritime economy. However, the dredging process can also cause negative impact on the environment, especially when the dredged soils are dumped into distant marine waters. Dumping activities from the dredging works could adversely affect the physical and biological elements of the sea. Contaminated dredged soils are harmful and could degrade the marine environment and result in long term, irreversible damages. Therefore, if a reuse potential can be derived for the dredged soils, dumping can be avoided and tge environmental and ecological impact can be avoided. The present study involve admixing chemicals with a dredged marine clay collected from the southern coast of India. Also geobags are used to improve the strength.

II. MATERIALS AND METHODS

A. Marine clay

The marine clay used in this study is typical soft clay which is collected at a depth of 0.3m to 1m from ground level in, Vishakapatanam, Andhrapradesh, India. The untreated marine clay after drying is shown in figure 1. The properties of soil are presented in Table 1. All the tests were carried on the clay are as per IS specifications.

Fig 1: untreated marine clay

Table 1: Properties of marine clay

Liquid limit	72%
Plastic limit	33.33%
Shrinkage limit	16%
Optimum Moisture Content	35.8%
Maximum Dry Density	1.36 g/cc
Unconfined Compressive Strength	0.332kg/cc
Specific gravity	2.62
Free Swell Index	8.5%
Natural Water Content	60%
Soil classification	CH

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B. Lime

Lime chemically known as, Calcium oxide (CaO), commonly known as quick lime or burnt lime, is widely used chemic. Th is a white, caustic, alkaline crystal solid at room temperature. It is useful for stabilization of clayey soil compound.

Fig 2 : Lime

When quick lime is added to the untreated marine clay it reacts with sufficient water to form a white powder. This process is referred to as slaking. Lime treated clay exhibit decreased plasticity, improved workability and reduced volume change characteristics.

C. Fly Ash

Fly ash is waste by product of thermal power plant. It is finely divided residue resulting from the combustion of ground or powdered coal from electric generating plants. Fly ash is air dreid and pulverized. The potential for using flya ash in soil stabilization has increased significantly in many countries due to the increased availability and the introduction of new environmental regulation that encourage the use of fly ash in geotechnical application since it is environmentally safe. The addition of fly ash imparts strength due to the process called hydration of fly ash. The formation of cementatious material by the reaction of lime with the pozzolans in the presence of water is known as hydration of fly ash.

D. Geobag

Natural geotextile is economical for the chemical physical combined method of stabilization. Hence the locally available jute is selected for the work. The purpose of geotextile in this study is to make geobag. Cylindrical shape geobags are preferred for this study. The prepared geobags are used for the curing of chemically treated marine clay. Mass per unit area of the chosen jute geotextile is 800g and thickness is 1.72 mm.

Fig 3 : Jute geotextile

Chemical Stabiliztion of Marine Clay

Chemical stabilization is the conventional method used for the improvement of weak soil. Here the locally available lime and fly ash were used for the stabilization of marine clay. First of all, lime is added to the marine clay in different percentages (2,4,6 & 8). Then the optimum percentage of lime is determined using UCS test. Now varying percentages of fly ash is added to the treated marine clay (with optimum percentage of lime). Another series of UCS tests were conducted to determine the optimum percentage of lime and fly ash when added together gives higher strength. Unconfined compressive strength was determined dafter curing. For moisture curing samples prepared were placed in polythene covers. Samples prepared for UCS tests were cured for 3,7,14 and 28 days and at the end of each curing period, the specimens were tested until failure. The mix proportion at which the samples give higher strength value is fixed and at that mix proportion specimens were prepared for tensile strength tests.

Unconfined Compressive Strength Test.

The primary purpose of the Unconfined Compression Test is to quickly determine a measure of the unconfined compressive strength of fine grained soils that possess sufficient cohesion to permit testing in the unconfined state. Unconfined compression tests are carried out on cylindrical specimens of 38mm diameter and 76mm height. The mix is to be compacted with optimum moisture content and maximum dry density.The specimens were cured for 3,7,14 and 28 days. Stress-strain behaviour and ultimate compressive strength of the treated marine clay are determined. The experimental combinations of clay-lime-fly ash to be undertaken as per Table 2 shown below:

Table 2 : Mix proportion of lime and fly ash

Sl. No	Mix proportion
1	Marine clay + 2% lime
2	Marine clay + 4% lime
3	Marine clay + 6% lime
4	Marine clay + 8% lime
5	Marine clay+6%lime+5% FA
6	Marine clay+6%lime+10% FA
7	Marine clay+6%lime+15% FA
8	Marine clay+6%lime+20% FA

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Split Tensile Strength Test

The marine clay is chemically treated with optimum percentage of lime and fly ash and which is used to prepare the specimens for split tensile strength test. The samples of sizes 38mm diameter and height of 76mm were prepared by static compaction method to achieve maximum dry density at their optimum moisture contents OMC. All the prepared samples were cured for 1 day, 3 days, 7 days and 28 days by maintaining 100% humidity. The sample is loaded until splitting/failure load takes after completion of their curing period at a strain rate of 1.25mm/min.

Curing with geobags

The geobags have been introduced for the curing of clay to be improved. Natural geotextile jute is used for making geobag. In this study, cylindrical shaped geobags having a diameter of 38mm and length 76mm are prepared and the specimens were placed inside the geobag. Specimens were cured for 3,7,14 and 28 days. During curing regular wetting of geobag is needed. After the samples have finished curing, the unconfined compressive strength tests were conducted to determine the q_u value and C_u value. The obtained results were compared with that without geobag.

For determining tensile strength variation, cylindrical shaped geobags having diameter 38mm and length 76mm are used. The treated marine clay with optimum percentage of lime and fly ash that gives higher UCS value were filled in the geobags. The specimens were cured for 3,7,14 and 28 days. The regular wetting of geobag is provided during the curing period. Sub sequently, after the samples have finished the predetermined curing period, geobags were cut open and then split tensile strength tests were conducted. The test results are compared with that values without wetted geobag.

III. RESULTS AND DISCUSSION

A. Unconfined Compressive Strength Test Results

1. UCS of marine clay with lime

Results of UCS of marine clay stabilized with different percentages of lime for different curing periods are analysed and the plot of UCS against curing period is shown in figure 4 given below.

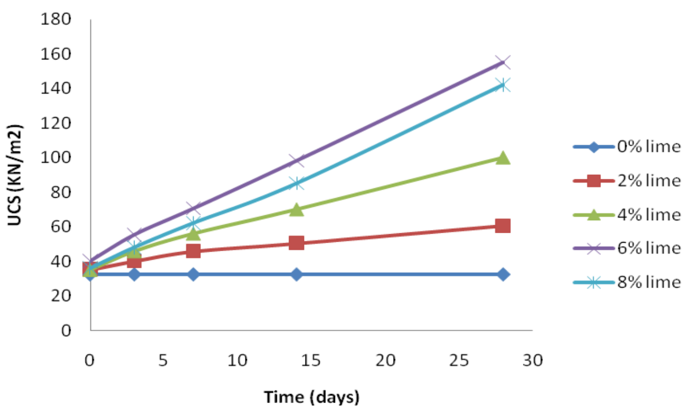

Fig 4: UCS of lime treated marine clay Vs curing time

The graph shows the variation of UCS with curing periods for various lime content. The UCS is seen to be directly proportional to the curing period for virtually all lime contents. Also from the graph it is clear that the UCS value increases with the increase in lime content initially. After a certain percentage the value decreases. The figure shows that for all cases 28 days cured sample gives highest strength compared to 0, 7 and 14 days cured sample similar to concrete because hydration will occur during the curing period due to the presence of cementicious materials in lime. The unconfined compressive strength was estimated from stress strain diagram. The unconfined compressive strength increases as the curing period increases for all the samples tested in this study.

It also shows that unconfined compressive strength increases for 0 - 6% lime content sample as lime content increases and then it reduces due to further increment of lime in the samples. The initial increment of unconfined compressive strength form 0-6 percent lime content sample might be due to the hydration of lime in the soil sample and the later (6 to 8 %) decrement of unconfined compressive strength might be due to the presence of excess lime (having less compressive strength compared to soil) in the soil sample. It is clear from the Figure that 6% lime content in the soil gives highest unconfined compressive strength at each curing period used in this study. Figure shows the plotting of unconfined compressive strength against four different curing periods for five different percentages of lime clay mixture. It shows that for marine clay (0% lime content) unconfined compressive strength is almost similar for all four curing periods indicating no effect of curing period on unconfined compressive strength for 100 percent clay. However, for other cases (lime clay mixture) considerable variation of unconfined compressive strength was observed with varying percentage of lime content in clay indicating the effect of lime content on unconfined compressive strength. Therefore, adding only 6% of lime with marine clay gives considerable improvement of strength property of marine clay.

2. UCS of marine clay with lime and fly ash

Results of UCS of lime treated marine clay stabilized with different percentages of fly ash for different curing periods are shown in the figure 5

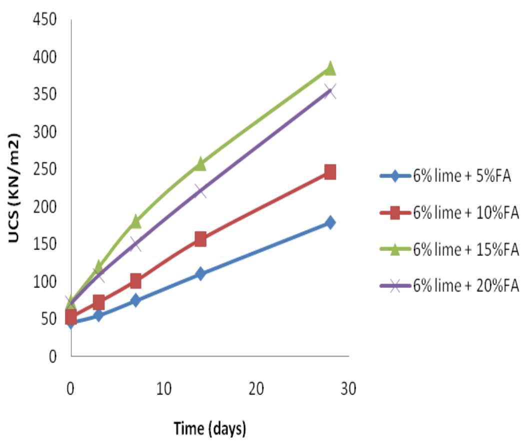

Fig 5: UCS of lime and fly ash treated marine clay Vs curing time

From the graph it is clear that the ucs strength is directly proportional to the curing time. The immediate strength increment is due to the process of cation exchange capacity and agglomeration. Further increment in strength after long term curing is due to pozzolanic reactions. Up to 15% of fly ash strength value increases after that it decreases. This percentage which gives the maximum strength is the optimum percentage. After the optimum percentage the decrease in strength is due to excess fly ash which is unreacted.

B. Split Tensile Strength Test Results

The split tensile strength tests were conducted for chemically treated marine clay with optimum percentage of lime and fly ash (6%lime and 15% fly ash). The tests results are given below.

Table 3: Split tensile strength of lime+fly ash treated marine clay

Sl. No	Curing period(days)	Tensile strength (N/mm2)
1	3	0.196
2	7	0.226
3	14	0.325
4	28	0.442

The split tensile strength value increases with the curing time and the maximum split tensile strength is achieved at 28 days of curing and is 0.442 KN/m2.

C. Curing with geobags

A. Comparison of UCS

When geobags are used as the containers of UCS samples, the regular wetting imparts higher strength the strength values. From the figure shown below, it is clear that this method gives higher UCS values as compared to the moisture method. Here also the strength is directly proportional to the curing period. Up to 6% of lime content strength increases and then decreases. Thus from the shown graphs the optimum percentage of lime content can be fixed as 6% which gives the higher strength.

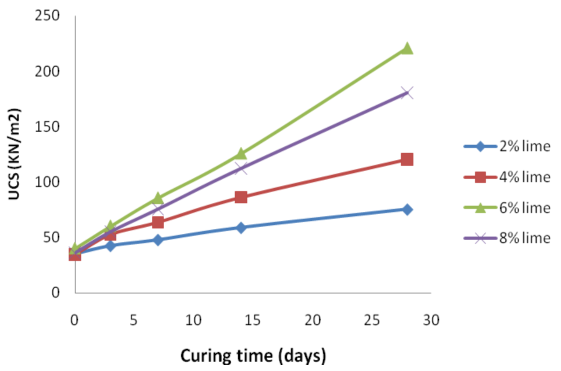

Fig 6 : UCS of lime treated marine clay Vs curing time (with wetted geobag)

Here also the maximum compressive strength is when 6% lime is used and is at 28 days of curing. When fly ash is added in varying percentage to the marine clay treated with 6% of lime and cured with wetted geobag the strength value increases. It can be understood from the following figure 7.

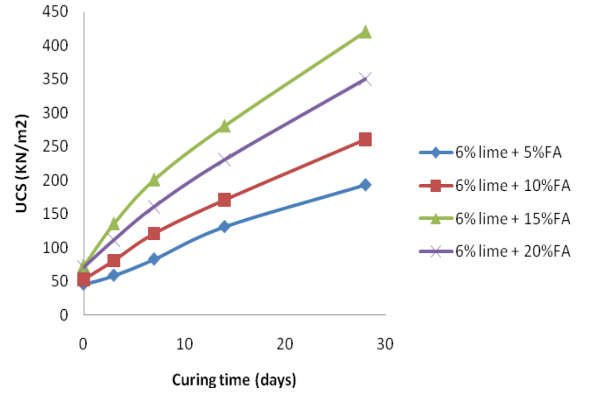

Fig 7: UCS of lime and fly ash treated marine clay Vs curing period

From the figure the maximum unconfined compressive strength of the treated marine clay can be seen which is at 28 days of curing and is 420.36 KN/m2.

B. Comparison of Shear Strength

The shear strength of the treated marine clay with or without using geobag can be analysed from the following figure 8. At 3 days of curing shear strength values are almost same for specimens cured with geobag and without geobag. After 3 days the shear strength values increases for both specimens used with and without geobag. But the shear strength values of specimens cured with wetted geobags are higher than that cured without geobag.The maximum shear strength is achieved at 28 days of curing and is 210.18 KN/m2. The addition of lime and fly ash together led to an increase in the unconfined compressive strength values for the studied marine clay strongly compared to the addition of lime and fly ash separately.

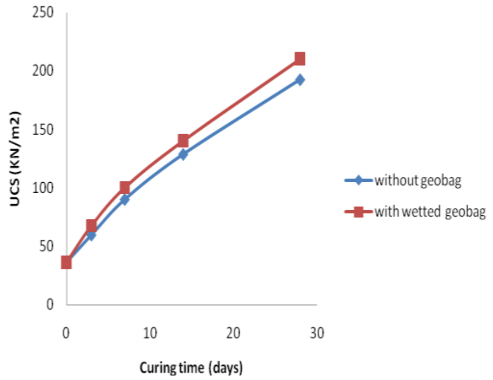

Fig 8: Shear strength of lime and fly ash treated marine clay Vs curing period

C. Comparison of Split Tensile Strength

It is clear from the graph; with wetted geobag the split tensile strength of treated marine clay is directly proportional to the curing time. Also the values are higher than that without geobag. The maximum shear strength is at 28 days of curing for both specimens cured with and without geobag. For specimen cured without geobag, 28 days strength is 0.421 N/mm2. But for specimens cured with wetted geobag, 28 days strength is 0.486 N/mm2.

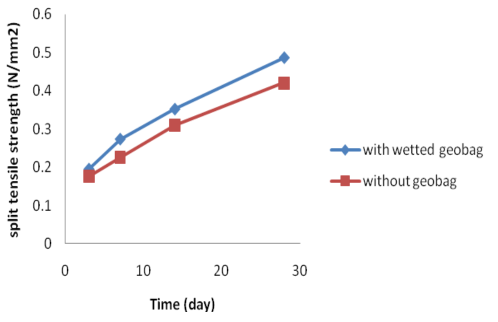

Fig 9 : Split tensile strength value Vs curing time

IV. CONCLUSION

The suitability of chemical physical combined method for the improvement of marine clay is studied by the experimental approach. The unconfined compressive strength and split tensile strength tests of lime and fly ash treated marine clay were conducted and the optimum percentage of lime and fly ash that gives maximum strength is determined. The strength values of specimens cured with and without geobags were compared. The following conclusions were obtained.

- When lime is added alone the optimum percentage obtained is 6% and the corresponding unconfined compressive strength is 155.26 KN/m2.
- The optimum percentage of lime and fly ash when added together is 6% and 15% respectively and the corresponding unconfined compressive strength is 385.47 KN/m2.
- The maximum split tensile strength value of lime and fly ash treated marine clay is 0.421N/mm2 and is achieved at 28 days of curing.
- When geobags are used for the curing of lime and fly ash treated marine clay, 9% increase in the maximum unconfined compressive strength is achieved as compared to that without using geobag.
- The increase in maximum split tensile strength value of treated marine clay cured with geobag is 15% to that without geobag
- Shear strength and tensile strength values indicated the suitability of reuse of dredged marine clay.
- Thus the chemical physical combined method of treatment can be used to reduce the environmental effects of offshore dumping of dredged soils and can be adopted in future for sustainable development of geotechnical engineering.

REFERENCES

[1] Ainum Nazhirin Abdul Jalil and Chee Ming Chan (2014) ‘Some insights to the Reuse of dredged marine soils by admixing with activated steel slag’, Advances of Civil Engineering,Vol.2014.

[2] A.S Indratna and A.K Baalasubramanian (1995) ‘Effect of fly ash with lime and cement on the behavior of a soft clay’, Journal of Engineering Geology and Hydrogeology, Vol 28(2), pp 131-142.

[3] Aydin Kavak and Fusun Tuylnce (2012) ‘Treatment of marine clay with hydrated lime and quick lime’, ASTM International

[4] Chee-Ming Chan (2016) ‘Geo parametric study of dredged marine clay with solididfication for potential reuse as good engineering soil’, Proc. Environmental Earth Sciences, 75(11).

[5] D.B Eme, J.C Agunwamba (2014)‘Tensile strength of natural and lime stabilized clay soil in Rivers state using an indirect tensile strength testing technique’ International Journal of Engineering and Science, Vol.3, pp38-45.

[6] Dr. Dongqing Wu (2015)‘Improvements of marine clay using chemical physical combined method’, Journal of Rock Mechanics and Geotechnical Engineering, Vol .7, pp220-225.

[7] Dr. DSV Prasad, H Venkateswarlu (2015) ‘Strength behaviour of marine clay treated with Rice husk ash’, International Journal of Engineering Sciences and Research Technology.

[8] K.L.A.V Harnadh, K. Nehemiya et.al (2015) ‘Characteristics of Soil treated with fly ash, lime and calcium silicate’, International Journal of Engineering Technology, Management and Applied Sciences, Vol 3 (11).

[9] Koteswara Rao D, M. Anusha (2012) ‘Laboratory study on the stabilization of marine clay using lime and saw dust’, International Journal of Engineering Science and Advanced Technology, Vol. 2 (4), pp851-862.

[10] Koteswara Rao D (2011) ‘A study on the influence of lime on fly ash treated marine clay’, International Journal of Engineering Science and Advanced Technology, Vol.3(8).

[11] Nor Zurairahetty Mohd Yunus, Aminaton Marto (2015) ‘Performance of lime treated marine clay on strength and compressibility characteristics’, International Journal of GEOMATE, Vol.8 (2), pp232-238.

[12] Peteris Skels, Thomas Ingeman- Nielsen et.al (2011) ‘Quick lime sedimentation of fine grained marine sediments in low temperature areas’, 3rd International Conference Civil Engineering’11 proc. 1 Buiding Materials.

[13] P.V.V Sathyanarayana, Ganapathi Naidu (2012) ‘A Study on the Strength Characteristics of Fly ash, Lime and Sodium silicate Mixtures at their Free pouring conditions’, International Journal of Computational Engineering Research, Vol 2 (4).

[14] Taka-aki Mizutani (2012) ‘Solidification Of Dredged Marine Clay For Sustainable Civil Engineering Applications: A Laboratory Study’, International Conference on Ecosystems and Biological Sciences.