IOSR Journal of Computer Engineering (IOSR-JCE)
e-ISSN: 2278-0661,p-ISSN: 2278-8727, Volume 21, Issue 4, Ser. III (Jul - Aug 2019), PP 01-11
www.iosrjournals.org

A Comparative Study on Strength Characteristics of Marine Clay Treated With Rice Husk Ash and Lime

M. Mnideep[1], D.Appanna[2]
[1]M.tech student Roll no- 17961D1916, Lenora Engineering College, Rampa chodavaram, E.G.Dist, AP, India.
[2] Assistant Professor, Department of Civil Engineering, Lenora Engineering College,Rampachodavaram, E.G.Dist, AP, India.
Corresponding Author: M. Mnideep

Abstract: *The soil found in the ocean bed is known as marine soil. It can even be located on shore as well. The properties of saturated marine soil differ significantly from moist soil and dry soil. The soils have higher proportion of organic matters. It is also an expansive soil, which shrinks or expands with varying moisture contents, and can damage foundations and structures. This caused expensive solutions in the construction of structures and roads in coastal regions. Alternatively, soil treatment is suggested to increase the strength of the soil to meet the construction requirement for foundation and also to achieve the specifications for development work. Providing uniform soil moisture next to under your foundation is the only best thing to reduce or minimize the damaging effects of expansive soil. The marine clay used in the present study is collected from the sea shore near UPPADA village, Kakinada, East Godavari , Andhra Pradesh. The main objective behind the collection of marine clay at that particular location is that the government of A.P recently announced the construction of fishing harbour at that place. So we preliminarily conducting tests to evaluate the strength characteristics of the clay. Accumulation of various waste materials is now becoming a major concern to the environmentalists. Rice Husk ash is one such by-product obtained from industries which are using Rice Husk as fuel. Rice Husk ash by itself has little cementitious value but in the presence of moisture it reacts chemically and forms cementitious compounds and attributes to the improvement of strength and compressibility characteristics of soils. So in order to achieve both the need of improving the properties of marine clays and also to make use of the industrial wastes, the present experimental project has been taken up. In this project the effect of Rice Husk ash and Lime on strength properties of marine clay has been studied.*

Date of Submission: 26-07-2019 Date of Acceptance: 12-08-2019

I. Introduction

1.1 GENERAL

In many cases, clay deposit layers which are widely distributed over the Seaside show various aspects according to the type of base rock or distribution Characteristics. Marine clay deposits are encountered in the coastal regions of the world. Marine clay is soft in consistency and is characterized by high compressibility and low shear strength. They are fine-grained soils with moderate to high clay fraction and are highly plastic in nature. Generally, marine clay deposits vary from 10 to 30m in thickness along the coastline. Calcareous material is expected to be present in these soils in the form of small-sized shells. The properties of these deposits are complex and diverse and they mainly depend on the minerals present and micro structural arrangement of the constituent particles.

The engineering properties like high compressibility, low shear strength and low permeability of marine clays pose serious challenges to geotechnical engineers in the various construction activities. Soils with the same liquid limit may have different plastic limits and shrinkage limits, thereby exhibiting different shrinkage or volume change behaviour. The clays can cause problems in several ways, ranging from major structural damage in houses to poor drainage in yards. Fortunately, most types of structural damage can be repaired. Some types of damage are much more common than others. The various types of damage can occur singly or in combination with each other. House problems usually develop slowly at first and then become more serious as the years go by.

Although the types of damage caused by Marine Clay can be grouped into a few categories, no two houses are alike. Building and foundation design, the age of the house, soil characteristics, yard grading, vegetative plantings and pavements etc. Marine clay can be located onshore as well. The marine clays are soft clays characterized by low shear strength and high compressibility. Marine clays form one of the important groups of fine-grained soils. These soils have high proportions of organic content and are very sensitive to change in the stress system, moisture content and system chemistry of the pore fluid. Due to rapid infrastructure development along the coastal area, lots of civil construction activities take place in marine clays throughout the world. In India, most of the areas consist of soft marine clay deposits. The presence of weak marine clays forces the use of expensive deep foundations.

Transportation is necessary for the proper functioning and development of economic activities for any country, which involves production and distribution of goods and services from one place to another. Performance and life of the road network are generally depending upon the design and construction. Subgrade is generally made up of locally available natural soils. The strength and performance of pavement are dependent on the load-bearing capacity of the Subgrade soil. In the case of poor soil in the construction site, the poor soil can be removed or replaced with the soil of high strength. Design of pavement is depended upon the strength of the subgrade soil, which affects the thickness of pavement ultimately increase the cost of construction. Improvement in load bearing capacity of soil will improve the load-bearing capacity of pavement and thus, pavement strength and its performance.

Soil stabilization is a technique to improve the soil parameters such as shear strength, compressibility, density, hydraulic conductivity etc. The techniques of soil stabilization can be categorized into a number of ways such as consolidation, vertical drains, vibration, surcharge load, admixtures, grouting and reinforcement and other methods. Geotechnical engineers around the world are in search of new alternate materials which are required both for cost- effective solutions for ground improvement and for the conservation of scarce natural resources.

In this work, it is attempted the study the effect of binary blends of Rice husk ash and Lime on the properties of weak marine clay.

1.2 MARINE CLAY

1.2.1 General

Soft marine clay is very sensitive to change the stress system, moisture content and system chemistry of the pore fluid. Geotechnical engineers feel a necessity to improve the behaviour of these deposits using any one of the available ground improvement techniques for the construction of foundations. Soft clays known for their high compressibility, low stiffness and low shear strength are always associated with the large settlement. The marine clay got cracks as shown in the plate on drying and in the worst cases the width of the cracks is almost 250mm to 500mm and travel down to 1.00m beneath the ground level. The marine clays are generally found in the states of West Bengal, Orissa, Andhra Pradesh, Tamilnadu, Kerala, Karnataka, Maharashtra and some parts of Gujarat. Marine or soft clays exists in these regions are weak and expansive in nature.

1.2.1 Origin of marine clay

The marine deposits are mainly confined along a narrow belt near the coast and generally derived from terrestrial sources. In the south-west coast of India, there are thick layers of sand above deep deposits of soft marine clays. These deposits are very soft to soft normally consolidated highly compressible clays. The sensitivity range is in the order of slight to medium sensitive and essentially inorganic in composition. The thickness of deposits varies from 5-20mt. The marine clays are soft and highly plastic. The deposits generally need a pre-treatment before application of an external load. The performance of these soft fine-grained deposits under different conditions of environment varies over wide limits. In order to improve the engineering behaviour of soils, several improvement techniques are available in geotechnical engineering practice. The fact that the selection of any one of these methods for any problem can be made only after comparison with other techniques proves that the method is well suited for a particular system.

1.2.2 Behaviour of marine clay

The soil found in the ocean bed is classified as marine soil. It can even be located onshore as well. The properties of marine soil depend significantly on its initial conditions. The properties of saturated marine soil differ significantly from moist soil and dry soil. Marine clay is microcrystalline in nature and clay minerals like chlorite, kaolinite and illite and non-clay minerals like quartz and feldspar are present in the soil. The soils have a higher proportion of organic matters that acts as a cementing agent. Clay is an impermeable soil, meaning it holds water, as opposed to permeable soil that allows water to rapidly drain, like gravel or sand. It is also an expansive soil, such as the marine clay which predominates in almost all countries of the world, which when shrinking or expanding, can damage foundations and structures. The shrink and swell movements are due to changes in soil moisture.

These soils suffer from high saturation, low density, and low shear strength, sensitivity and deformation problems and are normally consolidated. The marine clays, because of the specific physio-chemical make-up, are subjected to volume change with the changes in their ambient environment. These soils are widely occupied in the coastal corridor and not easy to avoid marine clay regions for the construction of pavements and foundations due to the population density. The marine clays are not suitable as pavement sub grade &

foundation soil beds and pose problems due to their inability of strength criteria. More and more construction projects are encountering soft clays and hence there is a need to better the strength properties of marine clays

1.2.3 PROBLEMS ASSOCIATED WITH MARINE CLAY

Dmage to Foundation Footings

(a) Damage To Foundation Walls
(b) Damage to Building and Yards Caused By Landslides
(c) Damage to Floor Slabs and Roadways
Damages to the Pavement Subgrades

1.3 REMEDIAL MEASURES TO OVERCOME PROBLEMS OF MARINE CLAY

If the soil has a high deformation, the preventive measures are required. These measures can be broadly classified into the following categories:

- Avoiding highly compressible soils
- Alterations to these soils

In case of foundations, Sand Cushion method, Stiffening the foundation by adopting Alterations, Mat Foundations, Heat treatment, Chemical stabilization, soil replacement technique are some of the remedial measures to overcome the problems of compressible marine clay soils.

In the case of Pavement subgrades, stabilization techniques can be adopted using various industrial waste considering the economy and also chemical additives for easy mixing and early results. The reinforcement techniques also play a vital role in improving the load carrying capacity of the marine clay beds.

1.3.1 Soil liquefaction Soil liquefaction

It is an element of geological engineering that is important for the construction of structures. Soil liquefaction occurs due to several reasons, including earthquakes and the making of quicksand. Builders conduct soil element analysis by soil test kits before construction.

Liquefaction and related phenomena have been responsible for tremendous amounts of damage in historical earthquakes around the world. In recent times, frequent earthquakes have occurred in the last few years and these events have made it even more important to study about soil liquefaction because the best way to minimize earthquake aftermaths is to study and understand every aspect associated with them. Effects of soil liquefaction in the design of new buildings and infrastructure such as embankment dams, bridges, and retaining structures have to be studied in detail to ensure erection of the strong and durable structure.

1.3.2 Mechanical, Physical and Chemical Alterations

This involves excavation of soil and replacement with non-expansive material, where the depth of active zone (depth from the ground surface wherein seasonal moisture fluctuations occur) is small and where a suitable replacement material is available. Sand cushion method and Cohesive Non-Swelling (CNS) layer method are very popular.

1.3.3 Sand Cushion Method

In this method, the entire depth of the clay stratum if it is thin, or a part thereof, if it is deep enough, is removed and replaced by a sand cushion compacted to the desired density and thickness. It was reported that swelling pressure varies inversely as the thickness of the sand layer and directly as its density. Hence, sand cushions are formed in their loosest state to avoid the possibility of excessively increasing the swelling pressure without, however, violating the criterion of bearing capacity. The basic philosophy of this method is that, in monsoon, the saturated sand occupies less volume, accommodating some of the heaves of underlying marine soil, and in summer, partially saturated sand bulks and occupies the extra space left by the shrinkage of the soil.

.1**.3.4 Cohesive Non-Swelling (CNS) Layer Method**

In this method, about top 1 m to 1.2 m of the soil is removed and replaced by a cohesive non-swelling soil layer. According to Katti (1978), with the saturation of soil cohesive forces are developed up to a depth of about 1.0–1.2 m and counteract heave. CNS layer creates an environment similar to that around 1 m deep in soil with equivalent cohesion to counteract heave.

In physical alteration, granular material is mixed with clay to minimize heave. However, the permeability of the resulting blend would be more than that of the soil resulting in a faster ingress of water into the soil. Chemical alteration involves the addition of chemicals to clay to reduce heave by altering the nature of clay minerals (Chen 1988). Lime treatment of expansive soils is the most widely used technique and the most effective technique of chemical alteration to minimize volume changes and to increase the shear strength of foundation soils. The usefulness of the treatment depends on the reactivity of the soil to lime treatment and the extent of dispersion of lime into the soil.

1.3.5 Lime-Slurry Pressure Injection (LSPI)

In pavements, a technique called Lime-Slurry Pressure Injection (LSPI) is also used for minimizing swelling of soils. In this technique, lime-slurry is injected into drill-holes under a pressure of 15 kg/cm2 (Chen 1988). In this technique, lime slurry penetrates into the fissures in the soil mass to a sufficient depth (usually 8 to 10 feet), and the lime-filled seams help control the soil water content, reduce volumetric changes and increase soil strength. However, for LSPI to be an effective technique, the clay soil must contain an extensive network of fissures. Otherwise, lime cannot penetrate into the relatively impermeable soil to an appreciable distance from the injection hole to form a continuous lime seam moisture barrier Lime-soil columns were also tried to stabilize clays in-situ. It was reported that diffusion of lime into the ambient soil is effective up to a radial distance of about 3 times the diameter of the lime-soilcolumn.

1.3.6 **Stiffening the Foundation and Superstructure**

Provision of RCC bands in the foundation, plinth and lintel levels is also suggested as cracks control measures in buildings.

1.3.7 Mat Foundation

Mat foundation receives and transmits the entire structural load to the under slab soil. These foundations may be economical on a long term basis, but involves high initial cost and would be a costly proposition in developing countries like India (Chen, 1988).

1.3.8 Stone Columns

The stone column technique was increasingly used for improving the load bearing capacity and to reduce the settlements soft soils. This technique was used effectively for the foundations of structures, earthen dams and raft foundations, where huge settlement is possible.

1.4 STABILIZATION

Stabilization is the process of blending and mixing materials with soil to improve the soil's strength and durability. The process may include blending soils to achieve a desired gradation or mixing commercially available additives that may alter the gradation, change the strength and durability, or act as a binder to cement the soil.Stabilization is commonly used for better soil gradation, reduction of the PI or swelling potential, and increased durability and strength. Soils stabilized by additives often provide an all-weather working platform for construction operations. These types of soil-quality improvements are referred to as soil modifications.

1.5 METHODS OF STABILIZATION

The two general stabilization methods are mechanical and additive. The effectiveness of stabilization depends on the ability to obtain uniformity in blending the various materials. Mixing in a stationary or travelling plant is preferred. However, other means of mixing (such as scarifies, ploughs, disks, graders, and rotary mixers) have been satisfactory. The soil-stabilization method is determined by the amount of stabilizing required and the conditions encountered on the project. An accurate soil description and classification are essential for selecting the correct materials and procedure. FM 5-410, Chapter 9, lists the most suitable treatments for various soil types to stabilize these soils for different objectives.

Mechanical

Mechanical stabilization is accomplished by mixing or blending two or more gradations of material to obtain a mixture meeting the required specifications. The blending of these materials may take place at the construction site, at a central plant, or at a borrow area. The blended material is then spread and compacted to the required densities by conventional means. If, after blending these materials, the mixture does not meet the specifications, then stabilization with an additive is necessary.

Additive

Additive refers to a manufactured commercial product that, when added to the soil in the proper quantities, will improve the quality of the soil layer.

Stabilization alters the following engineering properties

- Increases load bearing capacity and shear strength of the soil
- Decreases the permeability and compressibility There are different types of stabilization. They are:

a) Mechanical stabilization
b) Cement stabilization

c) Lime stabilization
d) Bituminous stabilization
e) Chemical stabilization
f) Thermal stabilization

1.6 OBJECTIVES OF THE STUDY

The objectives of the present experimental study are to develop correlations between engineering characteristics of marine clay.

- To determine the characteristic of marine clay, in particular, the basic Properties, strength and compressive characteristics.
- To improve the strength characteristics of marine clay.
- To evaluate the performance of stabilized Marine clay with an optimum of rice husk ash and lime.
-

II. Review Of Literature

"PERFORMANCE OF LIME-TREATED MARINE CLAY ON STRENGTH AND COMPRESSIBILITY CHARACTERISTICS" by Nor Zurairahetty Mohd Yunus, Aminaton Marto, Faizal Pakir, Khairulanam Kasran, Mohd Akmal Azri Jamal, Siti Norafida Jusoh and Norliana Abdullah (2010). The physical properties of untreated and treated lime stabilized the marine clays were investigated and discussed in this study. Plasticity chart the marine clay can be classified as MH which is high silt. Since the value of Plastic Index (PI) is more than 10, the marine clay is suitable to be stabilized with lime. From the Standard Proctor Compaction Test, the maximum dry density (MDD) and optimum moisture content (OMC) is 1.55 Mg/m3 and.20 % respectively while the specific gravity is 2.62. From the Unconfined Compression Test (UCT) test, it was illustrated that the strength development after 7 days is less significant. This is due to the process of modification. However, the strength treated soils increases rapidly at 28 days curing period. This phenomenon could be related to the process of stabilization. Overall, this study proves that when lime is added into soils, the reactions between lime and clay particles change the properties of soils and these would increase the compression strength and shear strength of soil, which marine claymore stable. The consolidation test concludes that the void ratio of the sample decreases as the percentage of lime content increases from 3% to 9%. Then, the coefficient of consolidation (cv) of soil specimens with the addition of lime decreases as the lime content increases compared untreated marine clay where specimen with 3% lime content increased about 18.4% from untreated marine clay at 7 curing period. Compression index (cc) value signifies the compressibility of a soil, cc value decreases as lime content increases.

"Abhishek Patil, Girish Waghere presents a paper on Experimental Review for Utilization of Waste Plastic Bottles in Soil Improvement Techniques(2010)" and analysis was done by conducting "Tri-Axial Test & Direct Shear Test" on soil reinforced with Plastic Bottles Strips of size 1cm x 1cm. The comparison of test results showed that the soil sample using plastic strips gives a better result than soil without plastic. The size and content of strips of waste plastic bottles have a significant effect on the enhancement of strength of the soil. In this review paper, we have taken Black Cotton Soil. The soil is tested with 1% plastic by weight & with naturally obtained Soil. and concluded that Our experimental results show that, after adding plastic in the soil, the cohesion of soil increased by 67.18% by Triaxial test similarly we have performed Direct Shear test on the same soil where we have found that the cohesion increased by 24%. On the above basis, we observed the increase in cohesive property of soil so bearing capacity of soil increases and settlement as well as compressibility decreases.

"A review on the geotechnical and engineering characteristics of marine clay and the modern methods of improvements Mohammed Ali Mohammed Al-Bared and Aminaton Marto (2012**)."** Marine clay is a soft soil that could be found widely at the coastal and offshore areas. This type of soil is usually associated with high settlement and instability, poor soil properties that are not suitable for engineering requirements and low unconfined compressive strength of less than 20 kPa. Considerable failure could occur even with light loads and it shows flat or featureless surface. This kind of soil is considered as problematic due to the existence of high moisture content and usually exists as a slurry with a noticeable percentage of expandable clay minerals. In this paper, the geotechnical, microstructure and engineering properties of marine clay are thoroughly reviewed and discussed. The properties include moisture content, particle size distribution, specific gravity, Atterberg limits, mineral compositions and shear strength. Moreover, due to the increasing demand for construction at coastal and offshore areas involving the marine clay, many attempts have been made to stabilize this kind of soil in order to solve the geotechnical related problems. Some of the common stabilization methods used to improve the properties of marine clay such as cement grouting, chemical additives and some environmental friendly additives are discussed. In long term, marine clay treatment using cement was found to be the best method. In addition, this paper serves as a guideline for the design and construction of projects on marine soils..

"A LABORATORY STUDY ON THE STABILIZATION OF MARINE CLAY

USING SAWDUST AND LIME", Koteswara Rao. D, M.Anusha, P.R.T. Pranav, G.Venkatesh(2013**).** It is noticed that the liquid limit of the marine clay has been decreased by 15.43% on addition of 15% Saw Dust and it has been further decreased by 27.50% when 4% lime is added. It is observed that the plastic limit of the marine clay has been improved by 4.08% on addition of 15% Sawdust and it has been further improved by 11.50% when 4% lime is added. It is observed that the plasticity index of the marine clay has been decreased by 26.47% on addition of 15% Sawdust and it has been further decreased by 49.57% when 4%lime is added. It is found that the O.M.C of the marine clay has been decreased by 15.37% on addition of 15% Sawdust and it has been further decreased by 17.91% when 4% lime is added. It is found that the M.D.D of the marine clay has been improved by 1.96% on addition of15% Sawdust and it has been improved by 1.10% when 4% lime is added.

"STABILIZATION OF MARINE CLAY USING JEROFIX IZABEL SANGEETHA,(2013)" The quality of soil used in construction affects the overall stability of a structure. Cohesion, the angle of internal friction, capillarity, permeability, elasticity and compressibility are the properties of soil taken into account while considering it as a construction material. Many stabilizers are available for improving the performance of soil as a construction material but the invention of new materials lead to the depletion of resources. This necessitates the need for a cost-effective and reusable stabilizing agent. Industrial effluents pose a threat to the environment due to the lack of efficient disposal methods. This paper focuses on the utilization of Jerofix for the stabilization of marine clay. Jerofix was added to marine clay at 10%, 20%, 30%, 40% and 50% to marine clay; the samples are analyzed for their variation in index and engineering properties. Liquid limit and plastic limit decreased on addition of Jerofix when compared with marine clay. Maximum dry density increased whereas the OMC showed a decreasing trend with the addition of Jerofix. Unconfined compression strength increased with the addition of Jerofix and a maximum value of 106kPa was obtained with the addition of 40% of Jerofix. CBR value of uncontaminated marine clay which was 3.85 increased to 6.04 with the addition of 30% of Jerofix. Thus it is suitable for construction of road embankment.

III. Methodology

In this chapter, the properties of different types of materials used during the laboratory experimentation were presented. And a brief description of the experimental procedures adopted in this investigation and the methodology adopted during the course of study are briefly presented.

3.1 MATERIALS USED

The details of the various materials used in laboratory experimentation are reported in the following sections.

Marine clay

Marine clay is a type of clay found in coastal regions around the world. In the northern, DE glaciated regions, it can sometimes be quick clay, which is notorious for being involved in landslides. Clay particles can self-assemble into various configurations, each with totally different properties. When clay is deposited in the ocean, the presence of excess ions in seawater causes a loose, open structure of the clay particles to form, a process known as flocculation. Once stranded and dried by ancient changing ocean levels, this open framework means that such clay is open to water infiltration. Construction in marine clays thus presents a geotechnical engineering challenge. The marine clay used in this study was typical soft clay. The marine clay was collected at a depth of 0.30m from ground level from Uppada area, Kakinada, Andhra Pradesh State, India. All the tests carried on the soil are as per IS specifications.

Rice Husk Ash

Rice milling generates a by-product known as a husk. This surrounds the paddy grain. During the milling of paddy, about 78% of weight is received as rice, broken rice and bran. Rest 22% of the weight of paddy is received as a husk. This husk is used as fuel in the rice mills to generate steam for the parboiling process. This husk contains about 75% organic volatile matter and the balance 25% of the weight of this husk is converted into ash during the firing process, is known as Rice Husk Ash (RHA). This RHA, in turn, contains around 85% - 90% amorphous silica. So for every 1000 kg of paddy milled, about 220 kg (22%) of husk is produced, and when this husk is burnt in the boilers, about 55 kg (25%) of RHA is generated. India is a major rice producing country, and the husk generated during milling is mostly used as a fuel in the boilers for processing paddy, producing energy through direct combustion and/ or by gasification. An about 20 million tone of RHA is produced annually. This RHA is a great environmental threat causing damage to the land and the surrounding area in which it is dumped. Lots of ways are being thought of for disposing of them by making commercial use of this RHA.

Table 3.1 Chemical Properties of Rice Husk Ash

CONSTITUENTS	COMPOSITION
SiO_2	86 %
Al_2O_3	2.6%
Fe_2O_3	1.8%
CaO	3.6%
MgO	0.27%
Loss in ignition	4.2%

USES OF RICE HUSK ASH

As a stabilizer The Rice Husk Ash would appear to be an inert material with the silica in the crystalline form suggested by the structure of the particles, it is very unlikely that it would react with lime to form calcium silicates. It is also unlikely that it would be as reactive as Rice Husk Ash, which is more finely divided. So Rice Husk Ash would give great results when it used as a stabilizing material.

Lime

The commercial Surya lime took from the market for the purpose of stabilizing soil, which imparts cementing property to the soil mix.

Properties of lime

- Lime is a white amorphous solid.
- It has a high melting point of 2600^{o}C.
- It is highly stable and even fusion cannot decompose it.

LABORATORY EXPERIMENTATION

The soil was initially air dried prior to the testing. The tests were conducted in the laboratory on the marine clay to find the properties of virgin marine clay.
The following tests were conducted as per **IS 2720** code of practice.

3.1.1 Free Swell Index (IS 2720 Part-40)
3.1.2 Specific gravity (IS 2720 Part- 2)
3.1.3 Grain size distribution (IS 2720 Part- 4)
3.1.4 Index properties –liquid limit, plastic limit (IS 2720 Part- 5)
3.1.5 Standard Proctor Test (IS 2720 Part- 7)
3.1.6 California Bearing Ratio Test (IS 2720 Part-16)
3.1.7 Unconfined Compression Strength Test (IS 2720 Part-10)

IV. Results And Analysis

A detailed discussion on the results obtained from various laboratory tests done on weak marine clay blended with different proportions of rice husk ash and lime are presented.

4.1 GENERAL

In the laboratory various experiments were conducted by mixing different percentages of rice husk ash and lime. Compaction, California bearing ratio, Unconfined compression strength tests were conducted with a view to determine the optimum combination of rice husk ash and lime as a stabilizer.
The influence of the above said materials on the compaction and strength properties were discussed in the following sections. In the laboratory all the tests were conducted as per IS codes of practice.

Table 4.1 Properties of Marine Clay (Experimental Values)

S. No	Property	Value
1	Specific Gravity	2.65
2	Differential Free Swell Index	40
3	Atterberg's Limits i) Liquid limit (%) ii) Plastic Limit (%) iii) Plasticity Index	 65.7 32.6 33.1
4	Grain Size Distribution i) Sand Size Particles ii)Silt & Clay Size Particles	 13 87
5	Compaction Parameters	
	i)Maximum Dry Density (g/cc)	1.65
	ii)Optimum Moisture Content (%)	22.22
6	Penetration Parameters	
	California Bearing Ratio (%)	

	At 2.5 mm	1.04
	At 5 mm	0.89
7	Unconfined Compressive Strength Test	
	i)Unconfined Compression Strength (qu) (MPa)	0.359
	ii)Shear Strength (S=qu/2) (MPa)	0.179

Table 4.2 Physical Properties of Rice Husk Ash

S.No	Property	Value
1	Grain size used for the stabilization	Passing through 4.75 mm
2	Specific Gravity	2.01

Table 4.3 Results of the tests conducted on marine clay blended with different percentages of rice husk Ash

R.H.A(%)	MDD(g/cc)	O.M.C(%)	C.B.R(%)		U.C.S(MPa)
			At 2.5 mm	At 5 mm	
0	1.65	22.22	1.04	0.89	0.359
2	1.66	16.22	4.31	3.67	0.366
4	1.66	19.4	3.12	2.97	0.326
6	1.54	25.4	2.52	2.38	0.316

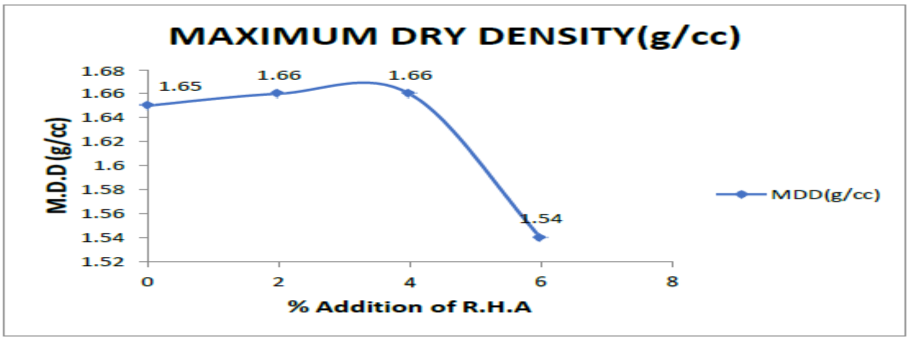

Fig 4.1 Plot showing the variation in MDD with different % of RHA

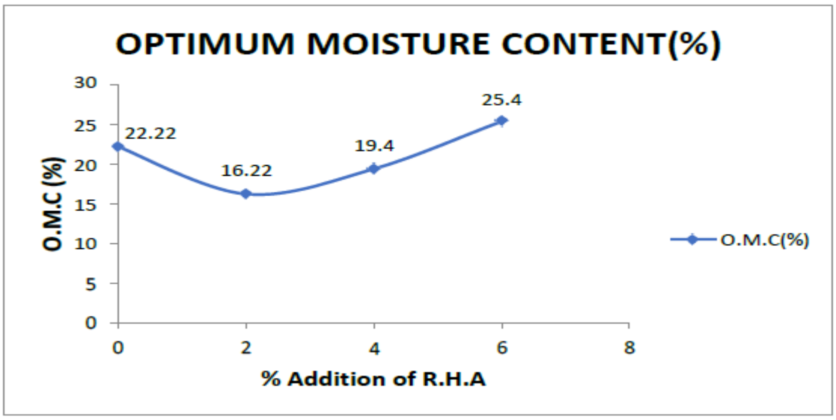

Fig 4.2 Plot showing variation in OMC with different % of RHA

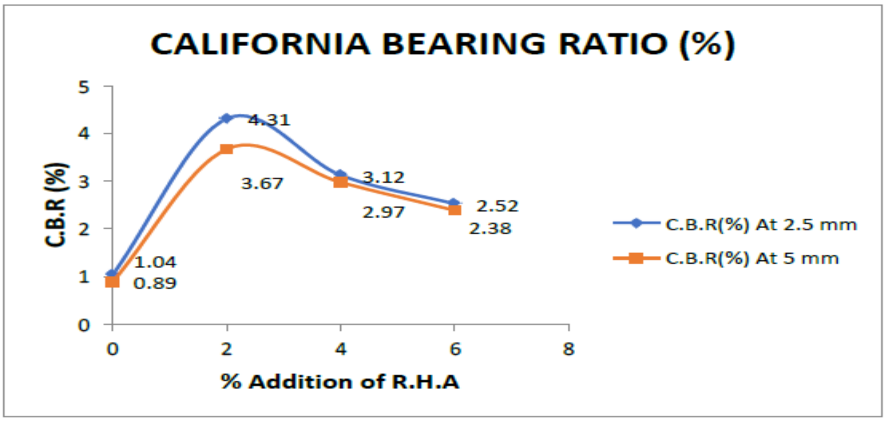

Fig 4.3 Plot showing variation in C.B.R with different % of R.H.A

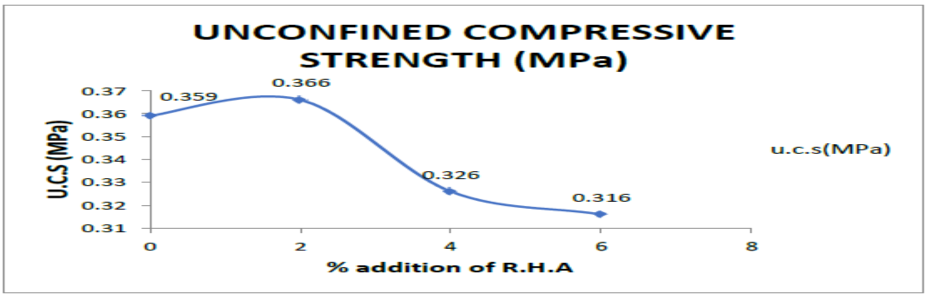

Fig 4.4 Plot showing the variation in U.C.S with different % of R.H.A

Table 4.4 Results of the tests conducted on marine clay blended with different percentages of lime

LIME (%)	MDD (g/cc)	O.M.C (%)	C.B.R(%)		U.C.S (MPa)
			At 2.5 mm	At 5 mm	
0	1.65	22.22	1.04	0.89	0.359
2	1.71	15.01	5.20	5.35	0.396
4	1.63	19.05	5.80	5.45	0.364
6	1.61	19.75	4.97	4.35	0.323

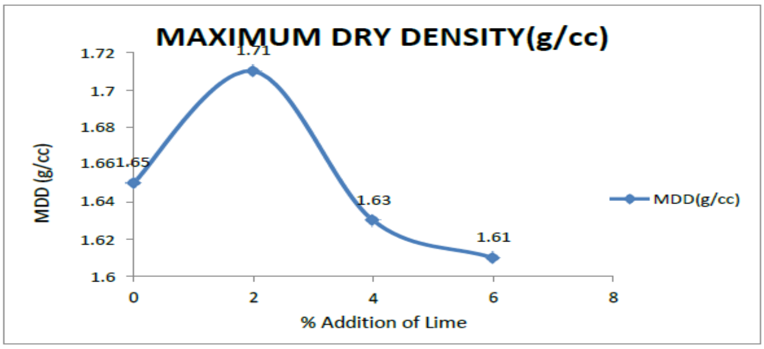

Fig 4.5 Plot showing the variation in MDD with different % of LIME

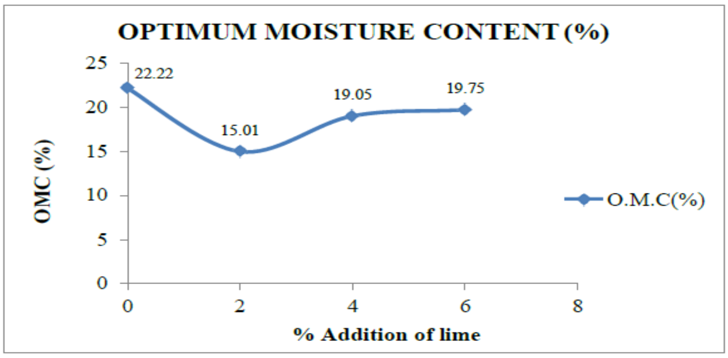

Fig 4.6 Plot Showing variation in OMC with different % of LIME

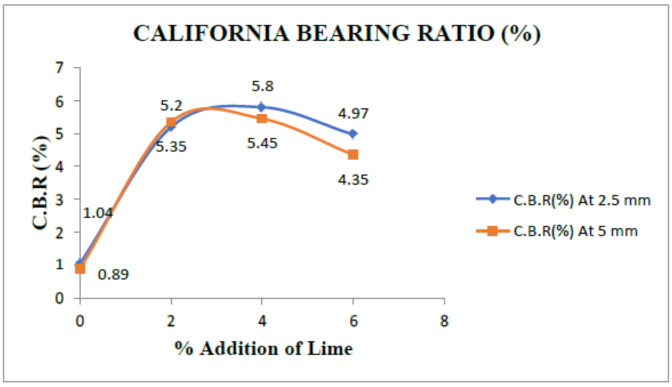

Fig 4.7 Plot showing the variation in C.B.R with different % of Lime

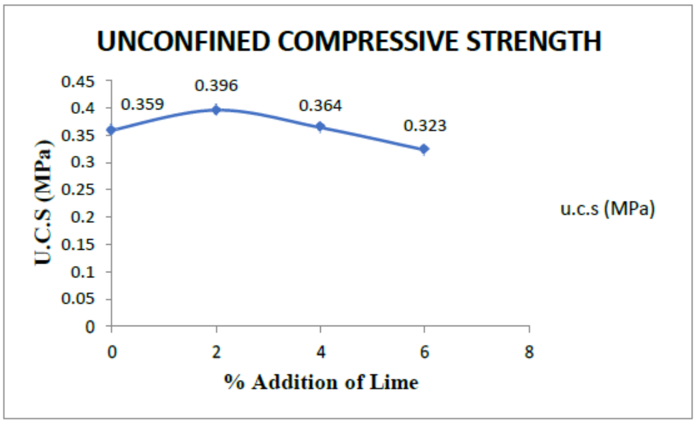

Fig 4.8 Plot showing variation in U.C.S with different % of Lime

V. Conclusions

The following conclusions are made based on the results obtained from laboratory experiments carried out in this investigation:

- The maximum dry density is increased from 1.65 to 1.66 when the soil is mixed with 2%rice husk ash and then decreased when further added and optimum moisture content is decreased from 22.22% to 16.2 % and increased when further added. In the same way M.D.D is increased from 1.65 to 1.71 when mixed with 2% lime and then decreased when further added and optimum moisture content is decreased from 22.22% to 15.01% and increased when further added.
- There is an improvement in C.B.R from 1.04 to 4.31 with addition of 2% R.H.A and decreased when further added. There is an improvement in C.B.R. from 1.04 to 5.35 with addition of 2% Lime and decreased when further added.
- Unconfined compression strength value is increased from 0.359 MPa to 0.366 MPa when 2% R.H.A is added and decreased when further added. Unconfined compression strength value is increased from 0.359 MPa to 0.396 MPa when 2% LIME is added and decreased when further added.
- On comparing the results obtained addition of lime shows more improvement in strength characteristics of marine clay than R,H.A.
- It is concluded that lime is best stabilizer when compared to rice husk ash.

References

[1]. PERFORMANCE OF LIME-TREATED MARINE CLAY ON STRENGTH AND COMPRESSIBILITY CHARACTERISTICS by Nor Zurairahetty Mohd Yunus, Aminaton Marto, Faizal Pakir, Khairulanam Kasran, Mohd Akmal Azri Jamal, Siti Norafida Jusoh and Norliana Abdullah (2010).

[2]. Review for Utilization of Waste Plastic Bottles in Soil Improvement Techniques by Abhishek Patil, Girish Waghere Experimental (2010).

[3]. A review on the geotechnical and engineering characteristics of marine clay and the modern methods of improvements by Mohammed Ali Mohammed Al-Bared and Aminaton Marto (2012**).**

[4]. A LABORATORY STUDY ON THE STABILIZATION OF MARINE CLAY USING SAWDUST AND LIME", Koteswara Rao.

D, M.Anusha, P.R.T. Pranav, G.Venkatesh(2013**).**
[5]. STABILIZATION OF MARINE CLAY USING JEROFIX by IZABEL SANGEETHA,(2013).
[6]. IMPROVEMENT IN CBR OF MARINE CLAY SUBGRADE STABILIZED WITH LIME AND ROCK DUST by E.Ramanjaneya Raju, D.Prudhvi Raju, G.L.V.Krishnam Raju(2013).
[7]. STRENGTH DEVELOPMENT OF SOFT MARINE CLAY STABILIZED WITH CEMENT AND FLY ASH" by Supakij Nontananandh, Sanupong Boonyong, Thakol Yoobanpot and Korchoke Chantawarangul (2013).
[8]. A LABORATORY STUDY ON THE EFFECT OF RICE HUSK ASH & LIME ON THE PROPERTIES OF MARINE CLAY BY DR D. KOTESWARA RAO, G.V.V. RAMESWARA RAO, P.R.T. PRANAV (2013).
[9]. EFFECT OF LIME ON GEOTECHNICAL PROPERTIES OF MARINE CLAY'' by Nusly k.Noohu (2017).
[10]. A Study On The Use Of DWP Inclusions In Quarry Dust And Lime Blended Weak Marine Clay.

M. Mnideep. " A Comparative Study on Strength Characteristics of Marine Clay Treated With Rice Husk Ash and Lime" IOSR Journal of Computer Engineering (IOSR-JCE) 21.4 (2019): 01-11.