Modification Studies on Marine Clay Reinforced With Jute Fiber And Treated With Phosphogypsum As A Stabilizer

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Abstract- *Marine Clays are with behaviour of low shear strength and high moisture content, thereby exhibiting high compressibility. Utilizing such clays for resting the foundations is almost impossible without some means of improving the adverse properties. This gives the need for thinking different alternate stabilization techniques in improving the behaviour of these marine clays. Although several methods, such as prefabricated vertical drains, Geotextile reinforcing, cement and lime stabilization, have been successfully implemented to treat such soils, there always remains the motivation for further improvement of the methods, especially in terms of efficiency. This gives the need for thinking different alternate stabilization techniques in improving the behaviour of these marine clays. The weak marine clay behaviour and the corresponding strength characteristics of these clays are improved by using various additives. The use of reinforcing elements is also being rapidly increasing these days. This led to initiate the present work in studying the effect of phosphogypsum on the properties of marine clay and reinforcing with jute fiber. A systematic methodical process was followed, involving experimentation in the laboratory under controlled conditions.*

Keywords- Marine clay, jute fibre, phosphogypsum, Atterberg’s limit test, CBR test, maximum dry density and optimum moisture contenttest.

I. INTRODUCTION

Marine clays located in coastal and offshore areas of the world forms one of the important groups of fine grained soils and lots of civil construction activities take place in such marine clays throughout the world. Since these clays are characterized by low strength and high compressibility, the design and construction of many coastal and offshore structures in these deposits are confronted with many geotechnical problems. Such low strength and high compressible soils are generally associated with increased moisture content and they are weak in strength due to the presence of swelling clay minerals such as montmorillonite, vermiculite and chlorite.

Growing population and acute shortage of land has led to land reclamation in many developed countries. For convenience of sea transport, many big cities in the world are located on clayey deposit around coastal area, thus large number of structures are built on soft soils. During the construction of these structures, the soil layer is subjected to a compressive stress, and it will exhibit a certain amount of compression. This compression is achieved through a number of ways, including rearrangement of the soil solids and / or extrusion of the pore air and/or water.

Soft soil formations, especially when the in-situ water contents are high, have very low bearing capacity and high compressibility characteristics. The in-situ deep mixing method is an established technique for improving the strength and reducing settlement of soft soil deposits. In practice, upon completion of the treatment, the improved ground will be cured over a specific period of time, before commencement of construction activities. At deeper depths, curing takes place under stress due to the overburden.

This process is generally referred to as soil stabilization, and in its widest meaning comprises every physical, physico-chemical, and chemical methods employed to enable a soil to serve better its intended engineering purpose.

Hence problematic soil like clayey soil must be adequately treated before the erection of structure. Wide range of soil modification method is available. Selection of appropriate method should be based on the type of soil and its characteristics, type of the construction , time available , associated cost.

It has been observed that industrial by-products can cause drastic change in the soil properties in terms of strength characteristics, density, acidity etc, arid also serves agricultural benefits by increasing crop yield. Moreover utilization of these products is a better solution to disposal than heaving them up on land.

In this work it is attempted the study the effect of binary blends jute and gypsum on the properties of weak clay.

1.2 OBJECTIVES OF THE STUDY

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

- Improvement of locally available soil using some eco-friendly and cheap waste materials.
- Evaluation of strength characteristics of virgin as well as blended soil using different length of Jute and Gypsum
- Determination of appropriate Jute fibre and phosphogypsum content ratio co achieve the maximum gain in strength of soil.

II. LITERATUREREVIEW

2.1Studies on marine clay

In general, the soils which are existing in the coastal corridors are Soft Marine Clays formed by the deposits and generally weak and possesses high deformation values in nature. It is essential to study the various techniques for the improvement of marine clays, especially in case of infra-structure development.

Santhi Krishna K, and Sayida M,K. (2009) conducted studies on the behaviour of black cotton soil reinforced with sisal fibre. The fibres were cut to different lengths (1.5cm, 2.0cm, 2.5cm and 3.0cm) and mixed randomly with soil in varying percentages (0.25%, 0.50%, 0.75% and 1.00%) by dry weight of soil and compacted to maximum dry density at optimum moisture content. The results showed a reduction in the maximum dry density and the optimum moisture content of soil due to ihe addition of sisal fibre.

Priya V.K. and Girish M. S. (2010) investigated the effect of inclusion of sisal Fibres on the compaction characteristics and unconfmed compressive strength of expansive soil treated with lime and to determine the plasticity characteristics of soil treated with lime. The soil samples were prepared at four different percentages of sisal fibre of length 25mm (0.25%, 0.5%, 0.75%) and 1% by weight of soil) and 5% percentage lime content, and unconfmed compression tests were carried out after 1, 3, 7, 14 and 28 day curing periods. The test results show that dry density of sisal fibre reinforced lime treated soil lower than that of unreinforced soil. But the opfimum moisture content is higher than that of unreinforced soil. The inclusion of fibre reinforcement within untreated and lime treated soil caused an increase in unconfmed compressive strength and changed the brittle behaviour of lime treated soils to more ductile one. The liquid limit values of expansive soil decreased with an increasing amount of lime content and curing time. Plasticity index also decreases with addition of lime.

S,A. Naeini and S. M. Sadjadi (2009) studied the effect of waste polymer materials on shear strength of unsaturated clays In the investigation, the waste polymer materials was chosen as the reinforcement material and it was randomly included m to the clayey soils with different plasticity indexes at five diffeient percentages of fibre content (0%, 1%, 2%), 3%, 4%) by weight of raw soil. The main objective of the study was focused on the strength behavior oi the unsaturated clayey soils, reinforced with randomly included waste polymer fibre. The reinforced soil samples were subjected to direct shear tests. The results have clearly shown a significant improvement in the shear strength parameters (C and (p) of the treated soils. The reinforcement benefit increased with an increase in fibre contents.

Kumar (2012) reported about the stabilization of black cotton soil using ground granulated blast furnace slag. A series of compaction and unconfmed compression tests were carried out on virgin as well as blended samples prepared. It was observed that with increase of slag, more stability of soil is achieved as compared to using lime alone. UCC strength of ordinary black cotton soil which was found out to be 188.5 kN/m , increased to 3429.37 kPa. The study recommended that for the proportion of (BC soil + 30% slag) + 4% lime @ OMC on 28'" day with proper curing, UCC strength increased up to 18 times that of ordinary black cotton soil and the use of slag as an admixture was recommended for improving engineering properties of the soils as an economical solution to use the locally available poor soil.

2.2 STABILIZATION

Soil stabilization is the process of altering some soil properties by different methods, mechanical or chemical in order to produce an improved soil material which has all the desired engineering properties. Soils are generally stabilized to increase their strength and durability or to prevent erosion and dust formation in soils.. The properties of soil vary a great deal at different places or in certain cases even at one place; the success of soil stabilization depends on soil testing. Various methods are employed to stabilize soil and the method should be verified in the lab with the soil material before applying it on the field.

3.2 METHODS OF SOIL STABILIZATION

- Mechanical Stabilization.
- Soil Cement Stabilization.
- Soil Lime Stabilization.
- Soil Bitumen Stabilization.
- Thermal Stabilization.
- Chemical Stabilization.

III. METHODOLOGY

MATERIALS USED AND THEIR PROPERTIES

3.1 Marineclay

Marine clay is a type of clay found in coastal regions around the world. In the northern, deglaciated 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 and was typical soft clay. The marine clay was collected at a depth of 0.30m to 1.00m from ground level from YETIMOGA area, Kakinada, Andhra Pradesh State, India. The properties of soil are presented in the Table 3.1. All the tests carried on the soil are as per IS specifications.

TABLE 3.1 Properties of Marine clay

S. No.	Property	Value
1	Specific gravity	2.61
2	Atterberg's Limits	
	i) Liquid limit (%)	63.3
	ii) Plastic limit (%)	32.2
	iii) Plasticity index (%)	31.1
5	Grain Size Distribution	
	i) Sand Size Particles (%)	10
	ii) Silt &ClaySize Particles (%)	90
6	IS soil classification	CH
7	Compaction Parameters	
	i) Max. Dry Density (g/cc)	1.33
	ii) Optimum Moisture Content (%)	30.9
8	Penetration Parameters	
	ii) CBR (%)	3
9	Shear Parameters at OMC & MDD	
	i) Cohesion, Cu (kPa)	41
	ii) Angle of Internal Friction, Øu (Degrees)	0

3.2JUTE FIBER

Jute is one of the most affordable natural fibers and is second only to cotton in amount produced and variety of uses of vegetable fibers. Jute fibers are composed primarily of the plant materials cellulose and lignin. It falls into the bast fiber category (fiber collected from bast, the phloem of the plant, sometimes called the "skin") along with kenaf, industrial hemp, fiax (linen), ramie, etc. The industrial lerinior jute fiber is raw jute. The fibers are off-white to brown, and 1-4 metres (3-13 feet) long. Jute is also called "the golden fiber" for its color and high cash value.

Jute Fibres have been purchased from the market. The Fibres are cut into pieces of approximately 20mm lengths and are mixed in percentage of 0.5%, 1%, 1.5% and 2% by dry weight of soil.

3.2PHOSPHOGYPSUM

Gypsum is a mineral which has properties that have long been familiar to man. The property of gypsum rock which enables it, after losing its water of crystallization through heating.to recombine with water to set into its original hard, rock-like state has increased its usefulness. Its widespread occurrence in nature has directed much attention towards its use for many industries. Historically, gypsum was first applied in ancient Ethiopia as a preserving material for the dead. Ancient Egyptians utilized gypsum in the construction of their pyramids. Later years saw France, Portugal, Greece, and Spain use gypsum to treat wine which made it ripen earlier. And so the use of gypsum in the early days became well known. Today, gypsum is quarried and produced commerically in many countries.

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 marineclay.

- Grain sizedistribution
- Specificgravity
- Index properties –liquid limit, plasticlimit
- Compaction tests
- Penetration tests-California bearing ratiotest.
- Unconfined CompressionTest-Triaxial

IV. RESULTS AND DISCUSSIONS

4.1GENERAL

In the laboratory, various experiments were conducted by replacing different percentages of Jute fiber (JF) in the Weak marine Soil and also further stabilizing it with Gypsum as a binder. Liquid Limit, Plastic Limit and Compaction, CBR and Triaxial shear tests were conducted with a view to determine the optimum combination of Jute fiber (JF) as replacement in weak marine soil and Gypsum as a binder. The influence of the above said materials on the Index, Compaction and Strength properties were discussed in following sections. In the laboratory, all the tests were conducted per IS codes of practice

4.2 EFFECT OF % JUTE FIBER (JF) AS REPLACEMENT ON THE PROPERTIES OF WEAK MARINE SOIL

The individual influence of Jute fiber (JF) on the Index, Compaction and Strength properties of marine soil are clearly presented in Figures 4.1, 4.5, 4.9, 4.13, 4.17, 4.21 and 4.25 respectively. The percentage of Jute fiber (JF) was varied from 0%, to 16% with an increment of 4%. From the above graphs, it was observed that the treatment as individually with 12% JF has moderately improved the marine soil. It can be inferred from the graphs, that there is a gradual improvement in the Plasticity index with an increment in % replacement of JF up to 16% with an improvement of about 11%. Also maximum dry density is improved by an amount of 2% and it was about 32% for cohesion and 64% for CBR respectively. Cohesion is increased from 00 – 20 for the increment of JF in marine soil from 0-20%.

4.3 EFFECT OF GYPSUM CONTENT ON THE PROPERTIES OF WEAK MARINE SOIL + JUTE FIBER (JF) MIXES

The influence of Gypsum as binder on the Index, Compaction and Strength characteristics of weak marine Soil + Jute fiber (JF) mixes are clearly presented in Figures 4.2-4.4, 4.6-4.8, 4.10-4.12, 4.14-4.16, 4.18-4.20, 4.22-4.24 and 4.26-4.28 for different percentages of Phosphogypsum respectively. The percentage of Phosphogypsum was varied from 0%, to 6% with an increment of 2%. In the laboratory, tests were conducted by blending different percentages of phosphogypsum to Weak Marine Soil + Jute fiber (JF) mixes with a view to determine its optimum blend. It is observed from the graphs, that there is an improvement in plasticity & Strength characteristics with an increase in the phosphogypsum content from 0% to 8% and it was found that for 2% addition of phosphogypsum there is an improvement of 7% for plasticity, 9% for MDD, 50% for cohesion and 75% for CBR respectively for an optimum of 2% gypsum. Also there is an improvement in Angle of internal friction by 5 times. From the above results it is evident that the addition of phosphogypsum to the JF– Weak Marine Soil mix had improved its characteristics.

Finally from the above discussions, it is clear that there is improvement in the behaviour of Weak Marine soil stabilized with Jute fiber (JF) + phosphogypsum. It is evident that the addition of Jute fiber (JF) to the virgin Marine soil showed an improvement in plasticity, compaction and strength properties to some extent and on further blending it with Gypsum, the improvement was more pronounced. This made the problematic weak marine soil which if not stabilized is a discarded material, a useful fill material with better properties. The Jute fiber (JF) replacement in the weak marine soil has reduced the plastic nature of the clay and upon further blending with Gypsum, the plasticity was even reduced. It can be summarized that the materials Jute fiber (JF) and phosphogypsum had shown promising influence on the properties of marine soil, thereby giving a two-fold advantage in improving problematic marine soil and also solving a problem of waste disposal.

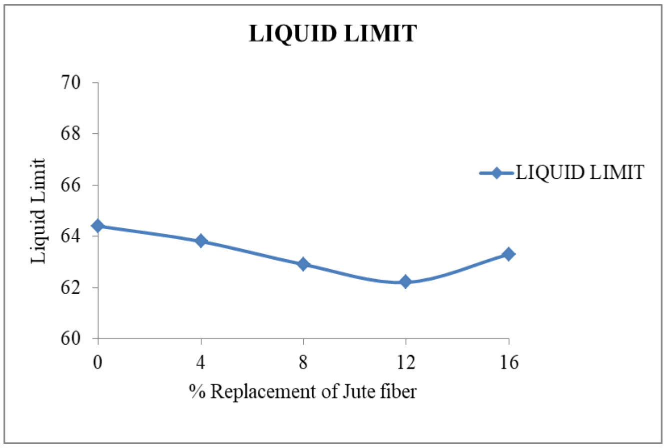

Fig. 5.1 Plot showing the variation of Liquid Limit with % of JF as replacement of Marine Soil for 2% Gypsum content.

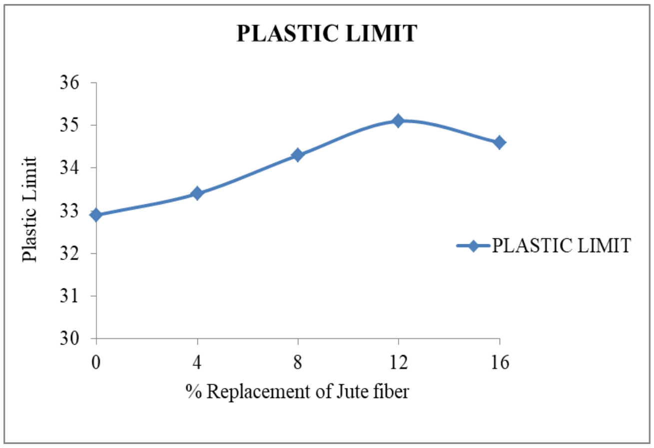

Fig.5.2 Plot showing the variation of Plastic Limit with % of JF as replacement of Marine Soil for 2% Gypsum content.

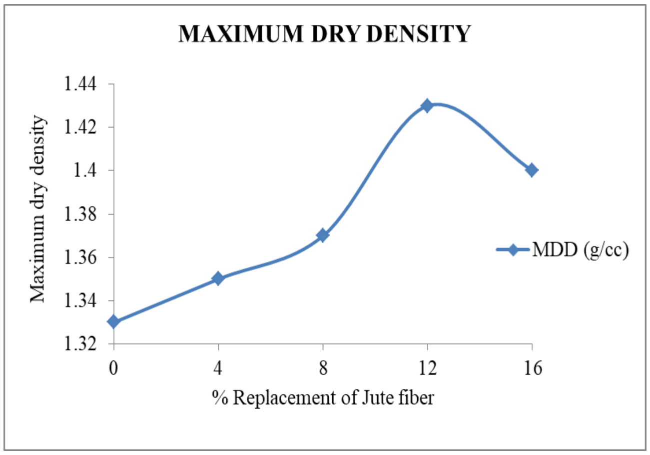

Fig.5.3 Plot showing the variation of Maximum Dry Density with % of JF as replacement of Marine Soil for 2% Gypsum content.

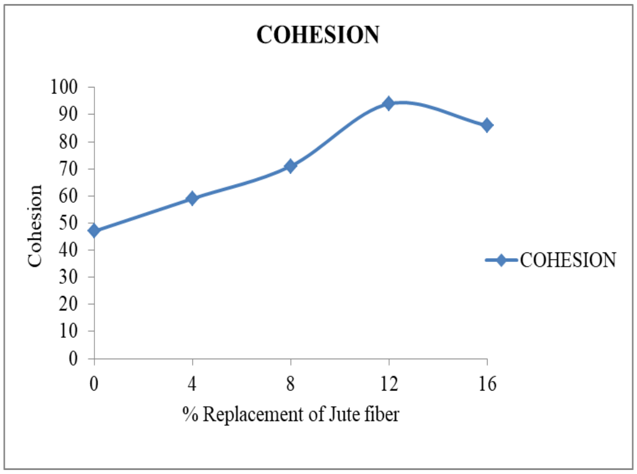

Fig. 5.4 Plot showing the variation of Cohesion with % of JF as replacement of Marine Soil for 2% Gypsum content.

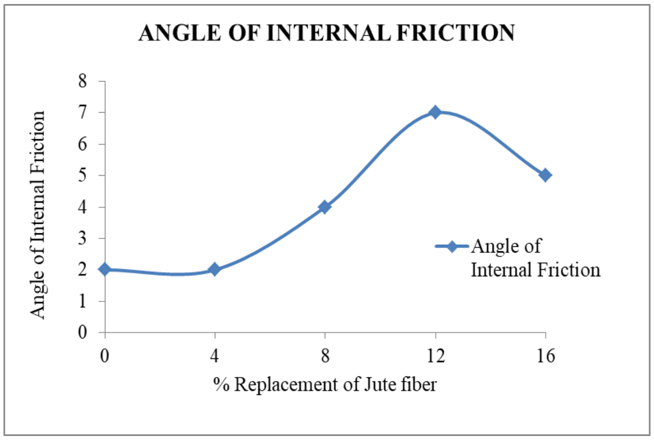

Fig. 5.5 Plot showing the variation of Angle of Internal Friction with % of JF as replacement of Marine Soil for 2% Gypsum content.

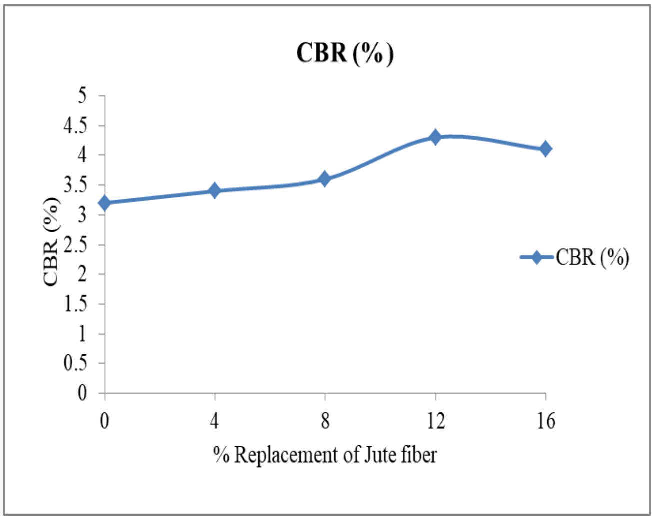

Fig. 5.6 Plot showing the variation of CBR with % of JF as replacement of Marine Soil for 2% Gypsum content.

V. CONCLUSIONS

The following conclusions are made based on the laboratory experiments carried out in this investigation.

- From the laboratory studies, it is observed that the Marine Soil chosen was a problematic soil having high swelling, and high plasticity characteristics.
- It was observed that the treatment as individually with 12% of jute fiber and 2% gypsum has moderately improved the marine soil.
- There is a gradual increase in maximum dry density with an increment in the % replacement of jute fiber up to 12% and phosphogypsum upto 2% with an improvement of about 8% for maximum dry density and it was about 12% for plasticity characteristics.
- There is an improvement in California bearing ratio values and shear parameters also by an amount of 50% for cohesion and 75 % for CBR.
- Angle of internal increased 5 times than parent soil for combination of 12% of jute fibre and 2% of phosphogypsum. Beyond that 4% addition of phosphogypsum also gives nearer values.
- It is evident that the addition of Jute fiber (JF) to the virgin Marine soil showed an improvement in properties to some extent and on further blending it with phosphogypsum, the improvement was more pronounced.
- Finally it can be summarized that the materials Jute fiber (JF) and phosphogypsum had shown promising influence on the properties of Weak Marine soil, thereby giving a two-fold advantage in improving problematic marine soil and also solving a problem of waste disposal.

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