A Study on The Use of Sodium Lignosulfonate And Nylon Fibers In Improving The RHA Stabilized Marine Clay

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Abstract- *Being a developing country for India has large area coming under coastal region and also it has been the habitat for considerable percentage of population. The most developing coastal stares of India like West Bengal, Orissa, Andhra Pradesh, Tamilnadu, Kerala, Karnataka, Maharashtra and some parts of Gujarat have effect of these Marine clays. Structurally marine clay creates lot of damages to the structures which have construct over them. Problems of marine clay have appeared as cracking and break-up of pavements, railway and highway embankments, roadways, building foundations, irrigation systems, water lines, and canal and reservoir linings. There are different problems are associate with these marine clays as they have natural water content has more than the Liquid Limit. In now a days there is a lot of research work done on the production of concrete in an economical way by using different waste materials produced from various sources like agriculture, industrial, transportation, textile and etc. There are lot of different waste materials (Rice Husk Ash, Flyash, Waste tyre rubber, Geo textiles and many) produced from different fields as mentioned above, based on the properties like type, size, reactive nature, availability of such a waste materials we can use those as a replacement or addition to the soil. This lead to initiate the present work in studying the effect of RHA (Rice Husk Ash), Sodium Lignosulphonate and Nylon fibers on the properties of marine clay.*

Keywords- Curing Period, Marine Clay, Nylon Fibers, RHA and Sodium Lignosulfonate

I. INTRODUCTION

India has large coastline exceeding 6000kms. In view of the developments on coastal areas in the recent past, large number of ports and industries are being built. In addition, the availability of land for the development of commercial, housing, industrial and transportation, infrastructure etc. are scarce particularly in urban areas. This necessitated the use of land, which has weak strata, wherein the geotechnical engineers are challenged by presence of different problematic soils with varied engineering characteristics. Many of these areas are covered with thick soft marine clay deposit, with very low shear strength and high compressibility.

Majority of the population in India depends on road-based transport. There are many deposits of fine clays on coastal corridor and those soils are suffering from high saturation, low density, low shear strength, sensitivity, and deformation problems and are normally consolidated. The marine clays, because of the specific physico-chemical make-up, are subjected to volume change with the changes in their ambient environment. These soils are widely occupied in costal corridor and not easy to avoid marine clay regions for the construction of pavements and foundations due to the population density.

These soils are generally found in the states of West Bengal, Orissa, Andhra Pradesh, Tamilnadu, Kerala, Karnataka, Maharashtra and some parts of Gujarat in India. So there is need to improve transportation and also the construction facilities in these coastal regions for easy access. Marine clays exist in these regions are weak and highly compressible in nature.

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 quantifying the properties of marine clays.

Objective

- To find the approach of techniques to overcome the problems created by marine clays with a view to adopt suitable procedure through critical review of literature.
- Laboratory experimentations will conduct to study the impact of proposed additives and admixtures on the properties of marine clays.

- To evaluate the performance of marine clay when stabilized with proposed additives and admixtures and their suitability for fill material and sub grade material.
- To investigate the suitability and adoptability of Nylon Fibers (NF) as discrete reinforcement.

II. REVIEW OF LITERATURE

Weak marine soil deposits have been found both on the coast and in several offshore areas spread over many parts of the world. When clay particles precipitate in salt water, there is a tendency for the clay particles to flocculate and stick together giving rise to some sort of edge-to-face arrangement. As a result, clay, silt, and fine sand particles settle almost at the same rate and the final sediment formed consists of particles with a very loose card house-like structure. Hence the marine sediments can be considered as loose sediments, usually formed with high void ratios. Problems are associated with these fine-grained soils deposited at a soft consistency. Fine-grained soils are very sensitive to changes in the stress system, moisture content and system chemistry of the pore fluid.

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.

PROBLEMS ASSOCIATED WITH MARINE CLAYS

- Damages to the Pavement Sub grades
  - Rutting
  - Longitudinal cracks
- Damages to the building foundations
- Damages to super structure
- Cracks in buildings

REMEDIAL MEASURES TO OVERCOME PROBLEMS OF MARINE CLAY

If 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 case of Pavement sub grades, 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 plays vital role in improving the load carrying capacity of the marine clay beds.

- Soil Replacement
- Sand Cushion Method
- Stiffening the Foundation and Super structure
- Mat Foundation
- Stone Columns
- Heat Treatment
- Stabilization

Figure1 *Marine Clay Showing Cracks*

STABILIZATION

Soil stabilization technology offers advantages in a wide variety of road stabilization applications from unpaved roads that will remain un-surfaced to roads that will receive running surface treatments. Roadbed stabilization treatments include native roadbed soils, old gravelled roads, or recycled roadway surface materials. We create a superior structure that maximizes potential road strength and extends the useful life of the road bed.

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:

- Mechanical stabilization
- Cement stabilization
- Lime stabilization
- Bituminous stabilization
- Chemical stabilization
- Thermal stabilization

STUDIES 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.

Shridharan A et.al (1989), reported the Engineering properties of Cochin and Mangalore Marine Clays. A research has been done on the Physico-Chemical effects on the engineering behavior of Indian marine clays by Rao, M.S et.al (1992)

Thiam-Soon et al (2002), reported on improving the strength of the marine clay by the stabilization technique. Chu, J et.al (2002), reported the consolidation and permeability properties of the Singapore marine clay based on the laboratory and field investigations.

Balasubramaniam, A.S et.al (2003), proved the effects of additives on Soft Clay behaviour and concluded that the strength characteristics of the soft clays are improved by using various additives.

Oh, E.Y.N et.al (2006), presented the engineering properties and the characterization of marine clay for road embankment design in coastal area and the engineering properties of the marine clay were improved using various stabilization techniques.

Matchala Suneel et.al (2008), represented the compressibility characteristics of Korean marine clay. W.L. Sing et.al (2008), reported an improvement in the engineering properties of peat soils stabilizing with cement and ground granulated blast furnace slag and proved a remarkable increase in the pH and unconfined compressive strength, significant reduction in linear shrinkage, compressibility and permeability of the stabilized peat soils.

Basack,S et.al (2009), reported that the Engineering characteristics of marine clay collected form Visakhapatnam, India and the physical, chemical and mineralogical properties were presented and the strength, stiffness of the soil water matrix were established.

D. Koteswara Rao et al.(2011) studied the efficiency of $CaCl_2$,KCl,GBFS with marine clay and the test results concluded that load carrying capacity of the marine clay foundation soil bed has been improved.

D. Koteswara Rao et al.(2012) studied the efficiency of Rice Husk Ash & Lime with marine clay and the test results concluded that load carrying capacity of the marine clay foundation soil bed has been improved.

III. METHODOLOGY

In this we will discuss about 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.

Materials Used and Their Properties

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

Marine Clay

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 of Marine Clay properties All the tests carried on the soil are as per IS specifications.

Table 1: Properties of Marine Clay

S. No.	Property	Value
1	Specific gravity	2.61
2	Differential free swell Index (%)	39
	Atterberg's Limits	
3	Liquid limit (%)	74.5
	Plastic limit (%)	30.8
	Plasticity index (%)	43.7
	Grain Size Distribution	
4	Sand Size Particles (%)	11
	Silt & Clay Size Particles (%)	89
5	IS soil classification	CH
	Compaction Parameters	
6	Max. Dry Density (g/cc)	1.35
	Optimum Moisture Content (%)	30.6
	Penetration Parameters	
7	CBR - Unsoaked (%)	3.1
	CBR - Soaked (%)	1.4
	Shear Parameters at OMC & MDD	
8	Cohesion, Cu (kPa)	37
	Angle of Internal Friction, Øu (Degrees)	0

RHA

Rice milling generates a by-product know as husk. This surrounds the paddy grain. During 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 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).

Table 2: *Properties of RHA*

S. No.	Property	Value
1	Specific gravity	2.1
	Atterberg's Limits	
2	Plasticity index (%)	NP
	Grain Size Distribution	
3	Gravel Size Particles (%)	0
	Sand Size Particles (%)	58
	Silt & Clay Size Particles (%)	42
	Compaction Parameters	
4	Max. Dry Density (g/cc)	1.18
	Optimum Moisture Content (%)	16.7

Table 3: *Chemicals Present in RHA*

S.No.	Chemical	Composition
1	SiO_2	86 %
2	Al_2O_3	2.6%
3	Fe_2O_3	1.8%
4	CaO	3.6%
5	MgO	0.27%
6	Loss in ignition	4.2%

Sodium Lignosulfonate

Lignosulfonate is waste product of paper and timber industry. It is a lignin – based polymer exacerbate that contains various hydrophilic gatherings including sulfonate, phenolic hydroxyl, and in addition alcoholic hydroxyl and hydrophobic gatherings including the carbon chain. At present numerous kinds of Lignosulfonate are accessible in showcase, in this examination we was utilized sodium Lignosulfonate. Chemical formula of the Lignosulfonate is $C_{20}H_{24}Na_2O_{10}S_2$

Nylon Fibers

Nylon Fibers are exceptionally strong, elastic and stronger than polyester fibers. In the present study, locally available Nylon Fibers collected. The quantity of these Nylon Fibers was varied from 0% to 1.5% by dry weight of soil + RHA + SL, with an increment of 0.5%.

List of Laboratory Tests

- The grain size distribution
- Specific gravity
- Swell Tests- Differential Free swell
- Index properties –Liquid Limit, Plastic Limit
- Compaction tests
- Penetration tests- California bearing ratio tests.
- Strength tests- Tri- axial shear tests

SAMPLE PREPARATION

The soil was initially air dried, pulverized and then was sieved through 4.75mm sieve, prior to the testing. The samples were prepared by mixing the pulverized and sieved soil with the needed stabilizing agents in dry condition and then required amount of water is added to make a consistent mix by thorough mixing. The following tests were conducted as per IS Codes of practice to assess the influence of RHA, Sodium Lignosulfonate and Nylon Fibers (NF) on the Soft Marine Clay.

i. Compaction tests
ii. Penetration tests- California Bearing Ratio test.
iii. Strength tests- Tri-axial shear test

The following table lists the different variables and their respective contents used in the present study.

Table 4 Different variables studied

S.No.	Stabilizing Agent	% Content
1	Rice Husk Ash (RHA)	0, 5, 10, 15 & 20
2	Sodium Lignosulfonate (SL)	0, 2, 4 & 6
3	Nylon Fibers (NF)	0, 0.5, 1.0 & 1.5

IV. RESULTS AND DISCUSSIONS

Details of the laboratory experimentation carried-out with different combinations of materials have been discussed in the previous chapter including the laboratory proctor's test and tri axial tests on untreated and treated marine clay.

Table 5 *Variation of LL, PL & PI with % of RHA*

S.No	% RHA	LL (%)	PL (%)	PI (%)
1	0	74.5	30.8	43.7
2	5	71.2	31.6	39.6
3	10	69.1	33.4	35.7
4	15	67.4	35.5	31.9
5	20	64.8	37.2	27.6

Table 6 *Variation Compaction Parameters with % of RHA*

S.No	% RHA	MDD (g/cc)	OMC (%)
1	0	1.35	30.6
2	5	1.34	31.2
3	10	1.32	32.5
4	15	1.29	33.7
5	20	1.26	36.4

Table 7 *Variation CBR with % of GGBS*

S.No	% RHA	CBR (S) (%)	UCS (kPa)
1	0	1.4	74
2	5	1.6	79
3	10	2.1	85
4	15	2.7	93
5	20	2.4	91

Table 8 *Variation of LL, PL & PI with % of SL*

S.No	SL (%)	LL (%)	PL (%)	PI (%)
1	0	67.4	35.5	31.9
2	2	63.8	38.6	25.2
3	4	60.1	40.7	19.4
4	6	56.5	42.3	14.2

Table 9 *Variation Compaction Parameters with % of SL*

S.No	SL (%)	MDD (g/cc)	OMC (%)
1	0	1.29	33.7
2	2	1.36	31.3
3	4	1.43	28.6
4	6	1.41	28.9

Table 10 *Variation CBR with % of Lime*

S.No	SL (%)	CBR (S) (%)	UCS (kPa)
1	0	2.7	93
2	2	4.1	128
3	4	5.6	153
4	6	4.9	140

Table 11 *Variation Compaction Parameters with % of NF*

S.No	NF (%)	MDD (g/cc)	OMC (%)
1	0	1.43	28.6
2	0.5	1.48	26.8
3	1	1.5	25.6
4	1.5	1.47	25.5

Table 12 *Variation CBR with % of NF*

S.No	NF (%)	CBR (S) (%)	UCS (kPa)
1	0	5.8	162
2	0.5	6.5	187
3	1	7.4	205
4	1.5	7.1	199

Table 13 *Variation of CBR with Curing Period*

S.No.	Curing Period (Days)	CBR (S) (%)	UCS (kPa)
1	1	7.7	203
2	7	7.9	221
3	14	8.3	245
4	28	8.5	257

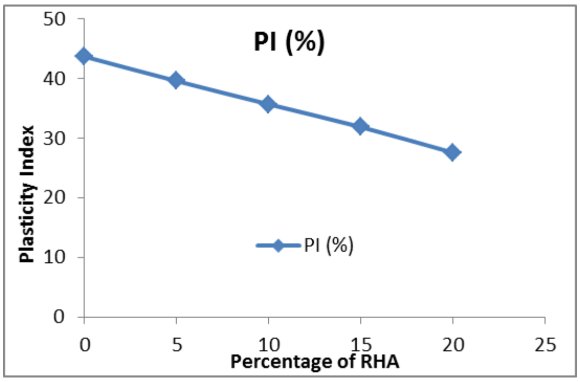

Figure 2: *Variation of P.I with % RHA*

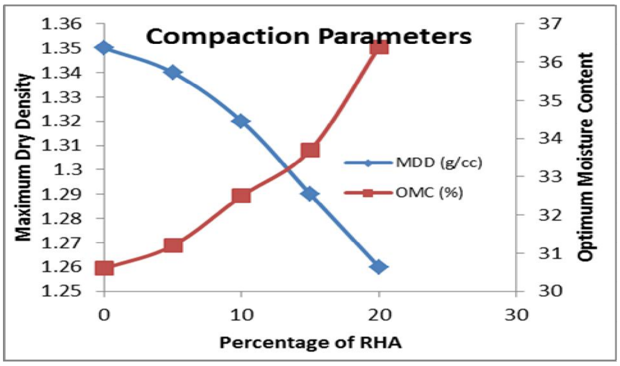

Figure 3: *Variation of Compaction Parameters with % RHA*

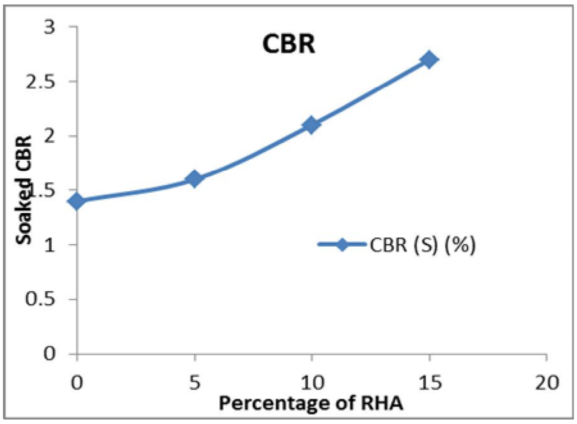

Figure 4: *Variation of Soaked CBR with % RHA*

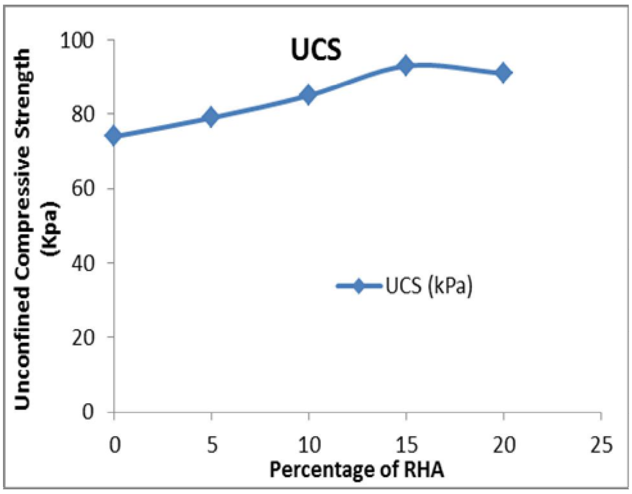

Figure 5: *Variation of UCS (kPa) with % RHA*

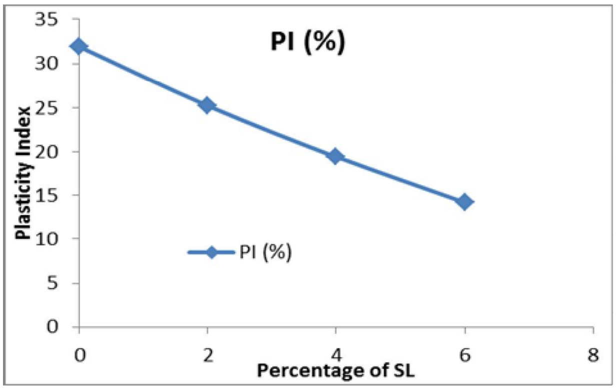

Figure 6: *Variation of P.I with % SL*

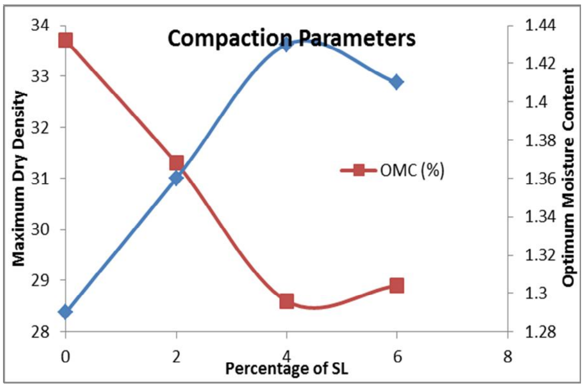

Figure 7: *Variation of Compaction Parameters P.I with % SL*

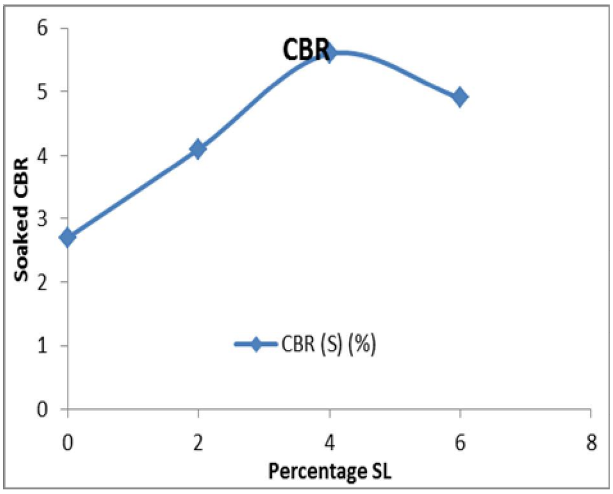

Figure 8: *Variation of Soaked CBR with % SL*

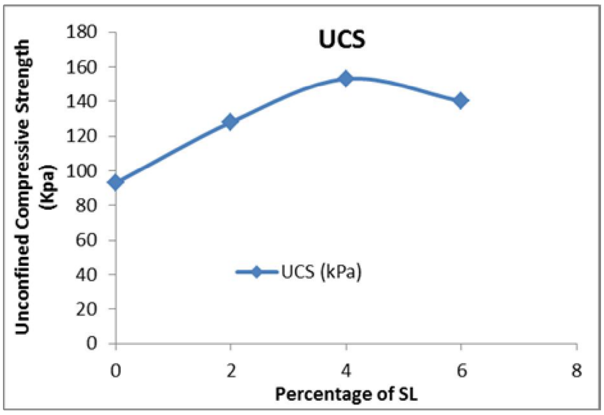

Figure 9: *Variation of UCS (kPa) with % SL*

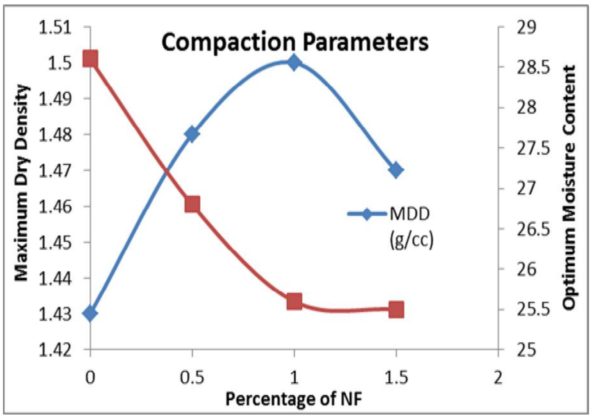

Figure 10: *Variation of Compaction Parameters with % NF*

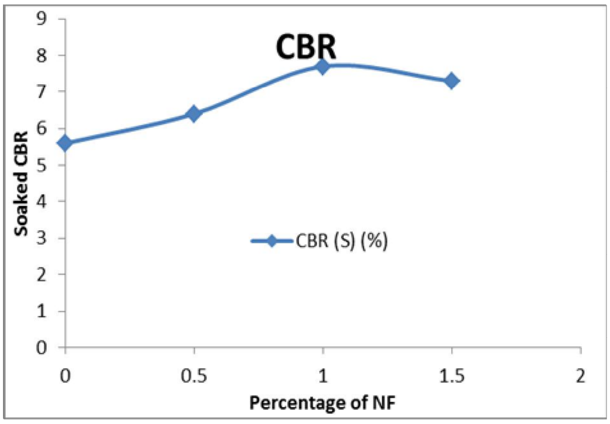

Figure 11: *Variation of Soaked CBR with % NF*

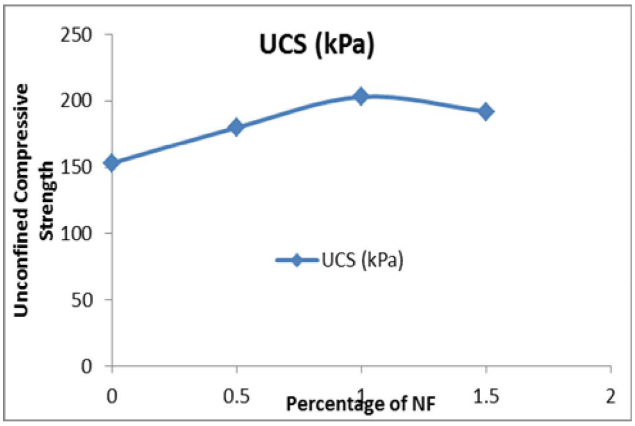

Figure 12: *Variation of UCS (kPa) with % NF*

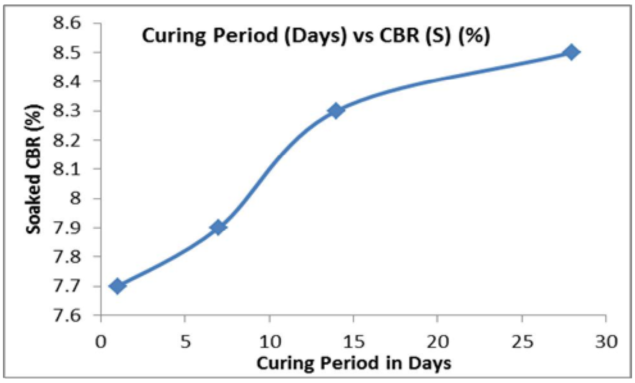

Figure 13: *Variation of Soaked CBR with different Curing Periods*

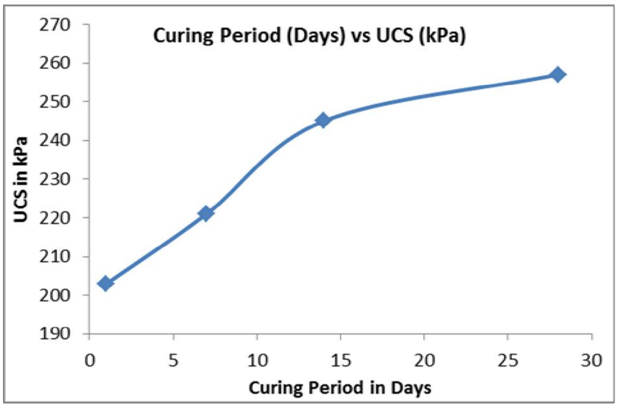

Figure 14: *Variation of Soaked UCS (kPa) with different Curing Periods*

EFFECT OF RHS, SODIUM LIGNOSULFONATE AND NYLON FIBERS ON THE BEHAVIOUR OF MARINE CLAY

Table 5 to Table 13 shows the summarized results of the behaviour of marine clay stabilized with RHS, RHS + SL, RHS + SL + Nylon Fibers (NF). From the table it is evident that the replacement of RHS to the virgin marine clay showed there is an decrease in MDD with increase in RHS from 5% to 20% it is due to the low specific gravity material (RHS) is replaced to more specific gravity material (Marine Clay) but, on further blending it with Sodium Lignosulfonate it increased by an amount of 5.9% when compared with virgin marine clay. The shear parameters also were improved with above mentioned materials. There is an improvement of 92.85% in soaked CBR original clay was replaced with 15% RHA and when it is further blended with Sodium Lignosulfonate, it improved by about 107.7% further. We can observe again improvement in soaked CBR at 1% NF added to the optimum mix Clay-RHA-LS by 32.67%. From Figure 2 to Figure 14 shows that variation of different properties at different combinations of materials. We can observe that the properties like Soaked CBR and UCS have shown improvement in the results up to 15% of replacement of RHS to the Virgin clay, where OMC & MDD get decreased, from the UCS and Soaked CBR results for the clay-RHS mix 85% of Clay + 15% of RHS can declare as optimum.

For that optimum mix again different % of Sodium Lignosulfonate is added to observe the variation in the different properties which resulted in improvement of Compaction Properties (OMC & MDD), Soaked CBR & Unconfined Compressive Strength up to 4%. Again for the mix of Clay-RHS-LS Nylon Fibers with 0.5%, 1.0% & 1.5% were added as reinforcement. Adding of Nylon Fibers (NF) shown that the improvement in the results. From the above discussions, it can be summarized that the materials RHA, Sodium Lignosulfonate and Nylon Fibers had shown promising influence on the properties of soft marine clay, thereby giving a two-fold advantage in improving problematic marine clay and also solving a problem of waste disposal.

V. CONCLUSIONS

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

The Marine Clay chosen was a problematic soil having high compressibility, with high plasticity and low strength characteristics. From the above discussions, tabulated and graphical results we can summarise that there is an increase in soaked CBR with an increment in the % replacement of Rice Husk Ash (RHA) up to15%. Again when the Clay-RHS mix blended with Sodium Lignosulfonate there is an improvement in the soaked CBR as well as MDD also. There is an improvement of 11.11% in Maximum Dry Density, 450% in Soaked CBR and 74% in Unconfined compressive strength at 85% Clay + 15% RHS + 4% Sodium Lignosulfonate + 1% Nylon Fibers compared to virgin soil. At different curing periods of above mentioned optimum mix we can observe the improvement in soaked CBR and also Unconfined Compressive Strength with increase in age of curing.

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