Effect of Bitumen And Coir Fibreon Engineering Properties of Marine Clayfor Foundation

V RAMYA SRI[1], D APPANNA[2]
[1]Dept of Civil Engineering
[2]Assistant Professor, Dept of Civil Engineering
[1, 2] Lenora College of Engineering, Rampachodavaram

Abstract- *Marine 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. All over the world, the problems of Marine Clay have appeared as cracking and breaking up of pavements, railways and highway embankments, roadways, building embankments, irrigation systems, water lines, canals, and reservoir linings.Soil stabilization has been extensively used for the improvement of these soft marine clays, in enhancing the shear strength and limiting the deformation behaviour.Bitumen is a binding material which is obtained from petroleum by- products. This can be used for pavements in various road construction works. Coir fiber is a degradable material, use of natural fibre for improving soil properties in civil engineering is a result of its low price, local availability, biodegradability and environmentally friendly. Both coir fiber and bitumen are mixed where coir fiber is not degradable. The marine clay stabilization mostly uses chemicals and other types of ashes. Here using the materials bitumen coated with coir fiber material. Keeping in view the research findings outlined above, in the present work, experimentation was carried out to investigate the effect of different additives bitumen and coir fibre in stabilizing the marine clay, thereby, improving the strength, swell characteristics of the marine clay. A systematic methodical process was followed, involving experimentation in the laboratory under controlled conditions.*

Keywords- Marine clay, Coir fibre, bitumen, Atterberg's limit test, CBR test, Un confined compression test, maximum dry density and optimum moisture contenttest.

I. INTRODUCTION

Soil is a fundamental engineering material. The quality of soil used in construction affects the overall stability of a structure. Cohesion, angle of internal friction, capillarity, permeability, elasticity and compressibility are the properties of soil taken into account while considering it as a construction material**.** 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 other. Construction works on soft clay foundations are often very challenging and very complex task since they are since they are generally characterized by its low strength properties. Still clayey soils are widely used for construction purposes due to economic reasons. Performance and life of road network is generally depending upon the design and construction. Sub grade is generally made up of locally available natural soils.

The strength and performance of a pavement is dependent on the load-bearing capacity of the Sub grade soil. In case of poor soil in construction site, the poor soil can be removed or replaced with the soil of high strength. Design of pavement is depend upon the strength of the sub grade 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. Soil stabilization can be explained as the alteration of the soil properties by chemical or physical means in order to enhance the engineering quality of the soil. The main objectives of the soil stabilization are to increase the bearing capacity of the soil, its resistance to weathering process and soil permeability. The long-term performance of any construction project depends on the soundness of the underlying soils. Unstable soils can create significant problems for pavements or structures, Therefore soil stabilization techniques are necessary to ensure the good stability of soil so that it can successfully sustain the load of the superstructure especially in case of soil which are highly active, also it saves a lot of time and millions of money when compared to the method of cutting out and replacing the unstable soil.

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 conservation of scarce natural resources. In this work it is attempted to study on improving marine clay sub grades with coir fibre and Bitumen.

1.2 OBJECTIVES OF THE STUDY

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

- To evaluate the performance of Marine Clay when treated with Coir Fibre as admixture.
- To evaluate the performance of Marine Clay treated with Bitumen coated coir fibre.
- To study the performance of treated marine clay as foundation beds

1. GENERAL

Transportation fulfills the basic need of humanity. For the time immemorial everyone travels either for food or leisure. There is a strong correlation between the quality of transportation facilities and development of country, because of which everyone places a great expectation from transportation facilities. Major challenges among civil engineers today is that transportation system must be analytically based, economically sound, eco-friendly, socially credible, sustainable and practically acceptable. In current scenario, conventional construction methods are unsuitable and driving interest in technologies like ground improvement. Among all transportation modes, economical road network plays a vital role for advancement in the economy of developing countries like India. In case of a highway, if the sub grade layer of the pavement is weak then they require greater thickness of pavement that results in increase of pavement constructioncost.

2. MARINECLAY

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 behavior of these deposits using anyone 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 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 groundlevel.

II. LITERATUREREVIEW

2.1 **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.

D. Koteswara Rao et al.(2011) studied the efficiency of CaCl2,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.

Rao et al. (2005) conducted the triaxial tests on sand reinforced with coir fibre. The aim of the experiment was to calculate the strength parameter the percentage of coir varied was 0.5% and 1%. He concluded that longer fibres were stiffer than the shorter ones the length of the fibre selected to study the stiffness of fibre was between 150-199 mm (type A1) and with fibre length less than 100 mm (type A2).for experimental work the length of fibre selected was 25mm. It was concluded that deviator stress at the time of failure increases with increase in the fibre content, at the lower value of confining pressures A2 type coir fibre shows higher value of deviator stress as compared to A1 type of fibre. At fibre content of 0.5% coir content A2 type shows higher strength than A1 type and at fibre content of 1% both A1 and A2 type shows near about similar strength when coir fibre was randomly distributed.

Chauhan et al. (2008) studied the effect of inclusion of coir fibre with polypropylene fibre in the silty sand mixed with fly ash. The percentage of fly ash was mixed at 10%, 20%, 30% and 40% of the dry weight of the soil and it was found that the optimum value percentage inclusion of fly ash was 30%. Both the fibres at 0.5%, 1%, 1.5% and 2% by dry weight were used in the study. UCS values increased up to 0.75% making it as an optimum value. Optimum dose of polypropylene fibre optimum dose was found out to be 1% finding from the triaxial tests resulted that the coir fibre exhibit more improvement in shear strength (up to 47.5%) of soil than the synthetic fibre(up to 70%).

Subaida et al. (2009) he reinforced the unpaved road with woven coir geotextile. It was concluded when geotextile was placed at mid- depth of base course there was significant increase in the value bearing capacity, further woven geotextile decreased the permanent vertical deformation when subjected to repeat loading by restraining the lateral spreading of base material. It wasconcluded that when coir geotextile was placed at sufficient height above the geotextile layer it mobilizes frictional resistance and help to decrease the damage caused to the geotextile due to traffic.

Dasaka and Sumesh (2011) reinforced the soil with the coir fibre at various fibre content and found that unconfined compressive strength increases for fibre content of length and improves ductile behaviour of soil a well-defined failure surface could not be seen due to increased ductile behaviour also peak compressive strength increased at the fibre content of 1.5% and thereafter value compressive strength becomes constant . When triaxial tests were conducted in the Unconsolidated Untrained (UU) condition under the various confining pressure it was concluded that ductility increases with increase in the fibre content and also the cohesion and friction angle was increased at the optimum fibre content of 1.5%.

Dutta et al. (2012) considered the impact of inclusion of coir fiber (15 mm long) in the unconfined compressive state of the soil. For treatment of dry fiber, sodium hydroxide and carbon tetrachloride were used. The sample for the unconfined compressive tests was set up with the fiber percentage inclusion of 0.4%, 0.8% and 1.6%. The axial stress increased from 63.98 kPa to 79.67 kPa was seen when clay was strengthened 0.4% dry fibre and with 1.6% inclusion of dry fibre strands increased up to 114.77 kPa. NaOH treated fiber the optimum value 0.4% axial stress of 81.47 kPa which on expanding the fiber substance to 1.6% raised to 130.03 kPa. Further, when the soil blend was fortified with 0.4% CCl4 treated filaments, the pinnacle pressure was 70.69 kPa, which again reached to 245.78 kPa when the fiber substance was increased to 1.6%.

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 differentproperties.

TABLE 3.1 Properties of Marine clay

S. No.	Property	Value
1	Specific gravity	2.61
2	Differential free swellIndex (%)	39
3	Atterberg's Limits	
	i) Liquid limit (%)	72.8
	ii) Plastic limit (%)	27.2
	iii) Plasticity index (%)	45.6
5	Grain Size Distribution	
	i) Sand Size Particles (%)	8
	ii) Silt &ClaySize Particles (%)	92
6	IS soil classification	CH
7	Compaction Parameters	
	i) Max. Dry Density (g/cc)	1.37
	ii) Optimum Moisture Content (%)	29.5
8	Penetration Parameters	
	ii) CBR - Soaked (%)	1.4

9	Shear Parameters at OMC & MDD	
	i) Cohesion, Cu (kPa)	12
	ii) Angle of Internal Friction, Øu (Degrees)	3.5

3.2COIR FIBRE

The fibre that was used in this study was coir fibre which is a fibrous material from coconut husk. The coir fibre is known as a material that is lighter, has high tensile strength, high hemicellulose, cellulose and lignin, which gives it lower degradation compared to other natural fibres. The material is also known to be environmentally friendly which benefits, nature where it can be used as soil reinforcement.

TABLE 3.2 Chemical properties of coir fiber

S.No	Chemical Composition	Value
1	Lignin (%)	45.84
2	Cellulose (%)	43.44
3	Hemi-cellulose (%)	00.25
4	Pectin's and related compound	3.00
5	Water soluble (%)	5.25
6	Ash (%)	2.22

3.2BITUMEN

Bituminous materials such as asphalts, tars, and pitches are used in various consistencies to improve the engineering properties of soils. Mixed with cohesive soils, bituminous materials improve the bearing capacity and soil strength at low moisture content. The purpose of incorporating bitumen into such soils is to water proof them as a means to maintain low moisture content. A bituminous material added to sand act as a cementing agent and produces a stronger, more coherent mass. The primary use of bituminous materials is in road construction where it may be the primary ingredient for the surface course or be used in the subsurface and base courses for stabilizing soils.

IV. 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

V. RESULTS AND DISCUSSIONS

5.1GENERAL

In the laboratory, various experiments were conducted by replacing different percentages of coir fibre and Adding bitumen to the optimum percentage in the Weak marine Soil. Liquid Limit, Plastic Limit and Compaction, CBR and UCS tests were conducted with a view to determine the optimum combination of coir fibre and as bitumen in weak marine soil and CBR and UCS are conducted for durability studies.

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.

5.2 EFFECT OF % COIR FIBRE ON THE PROPERTIES OF WEAK MARINE SOIL

The individual influence of coir fibre on the Compaction and Strength properties of marine soil are clearly presented in Table 6.1 and Figures 6.1, 6.2, 6.3, 6.4, 6.5 and 6.5 respectively. The percentage of coir fibre was varied from 0%, to 1% with an increment of 0.25%. From the above graphs, it was observed that the treatment as individually with 0.75% coir fibre 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 coir fibre up to 0.75% and also maximum dry density is improved by an amount of 7.9% and it was about 84.4% for UCS and 172% for Soaked CBR respectively. It was noticed that when the Marine Clay was treated with 0.75% coir fiber the angle of internal friction values are increased by 48.57 % when compared with untreated Marine Clay.

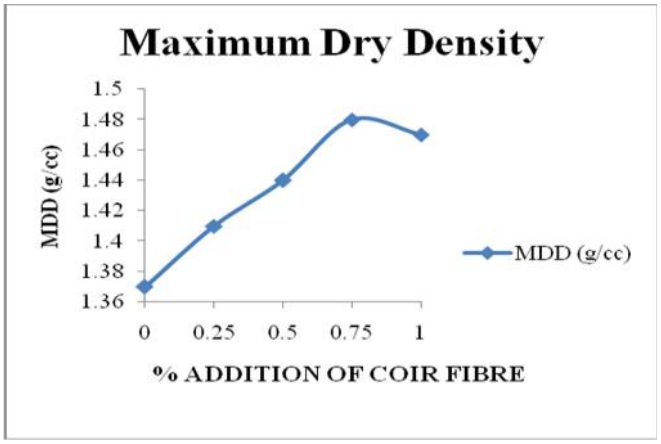

Fig 6.1 Plot showing the Variation in MDD with % addition of coir fibre

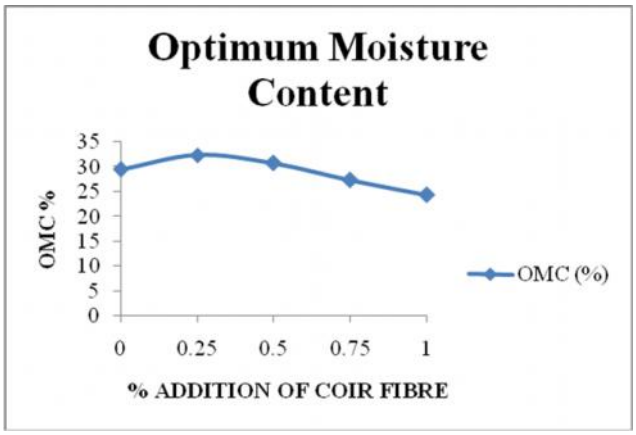

Fig 6.2 Plot showing the Variation in OMC with % addition of coir fibre

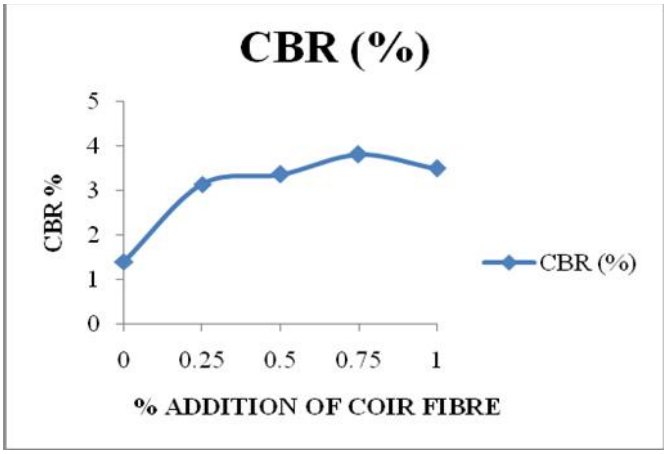

Fig 6.3 Plot showing the Variation in CBR VALUES with % addition of coir fibre

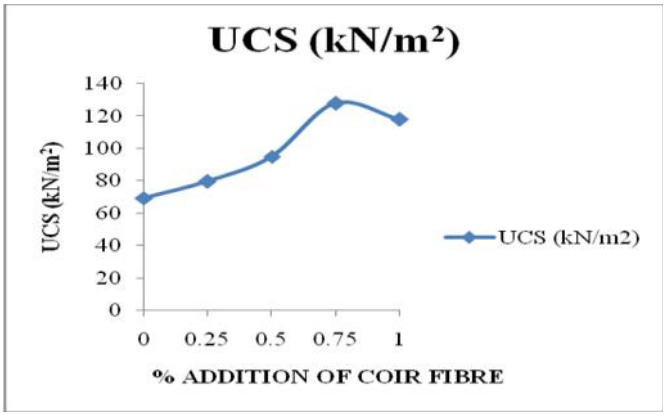

Fig 6.4 Plot showing the Variation in UCS with % addition of coir fibre

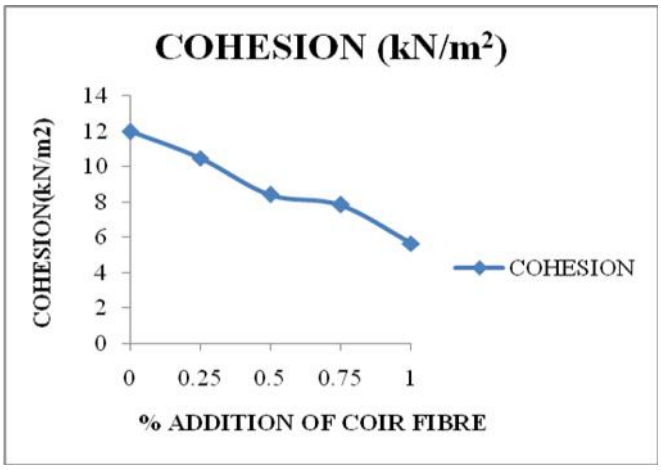

Fig 6.5 Plot showing the Variation in cohesion with % addition of coir fibre

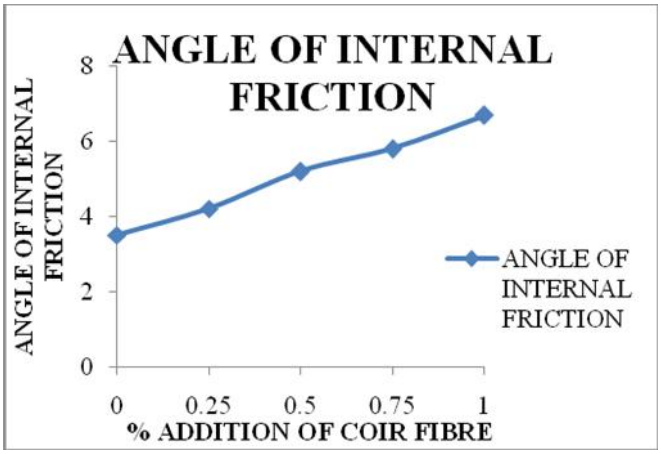

Fig 6.6 Plot showing the Variation in angle of internal friction with % addition of coir fibre

It can be inferred from the above results the treatment as individually with 0.75% coir fibre has moderately improved the marine soil. The optimum

content of coir fibre as % replacement of marine clay is 0.75%.

5.3 EFFECT OF % BITUMEN AS BINDER ON THE PROPERTIES OF WEAK MARINE SOIL

The influence of bitumen on the Index, Compaction, CBR, UCS properties of marine soil are clearly presented in Table 6.2 and Figures 6.7, 6.8, 6.9, 6.10, 6.11 and 6.12 respectively. The percentage of bitumen was varied from 0% to 5% from the above graphs, it was observed that the treatment with 3% bitumen 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 % addition up to 3%. Also maximum dry density is improved by an amount of 7.15% and it was about 19.6% for UCS and 26.5% Soaked CBR respectively. It was noticed that when the Marine Clay was treated with 0.75% coir fiber the angle of internal friction values are increased by 37.33 % when compared with untreated Marine Clay.

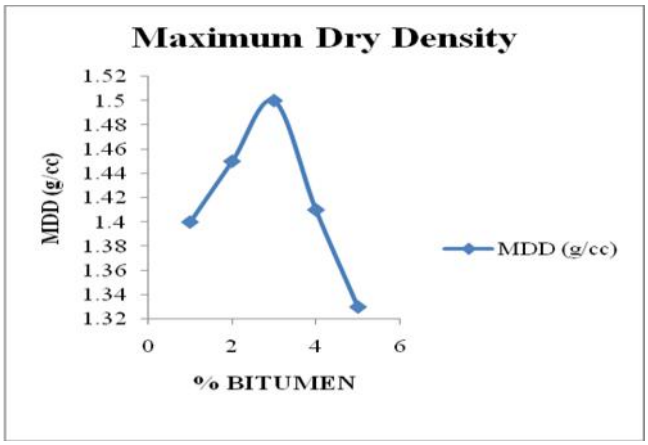

Fig 6.7 Plot showing the Variation in MDD with different % bitumen

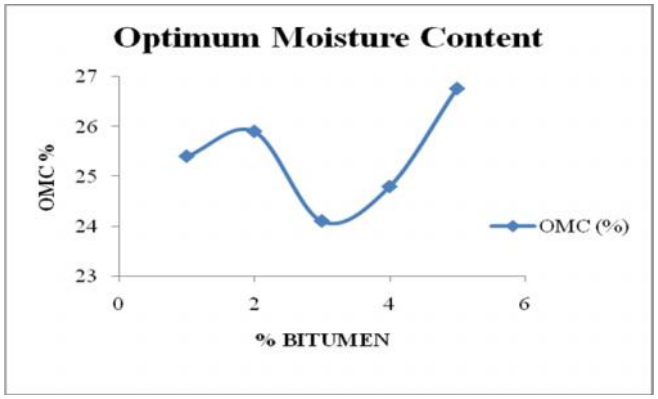

Fig 6.8 Plot showing the Variation in OMC with different % of bitumen

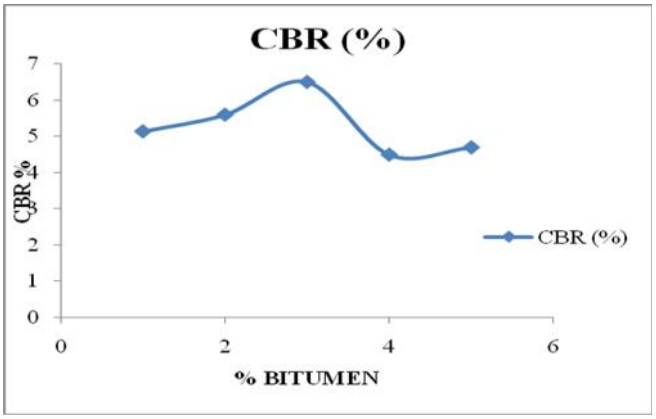

Fig 6.9 Plot showing the Variation in CBRwith different % of bitumen

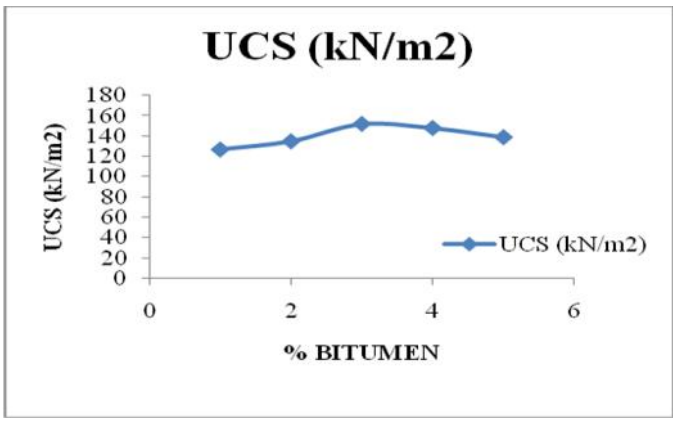

Fig 6.10 Plot showing the Variation in UCS with different % of bitumen

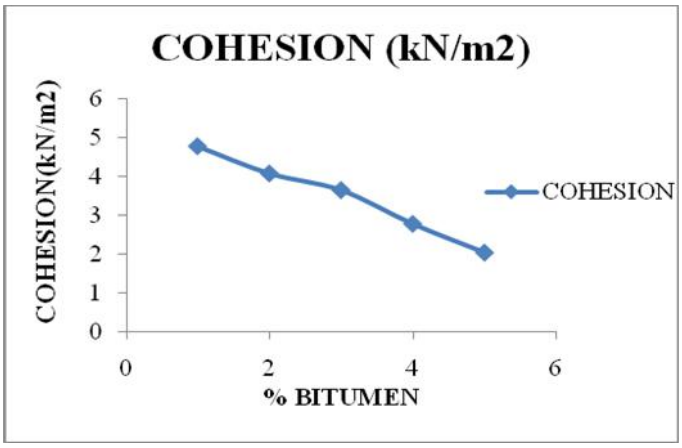

Fig 6.11 Plot showing the Variation in cohesionwith different % of bitumen

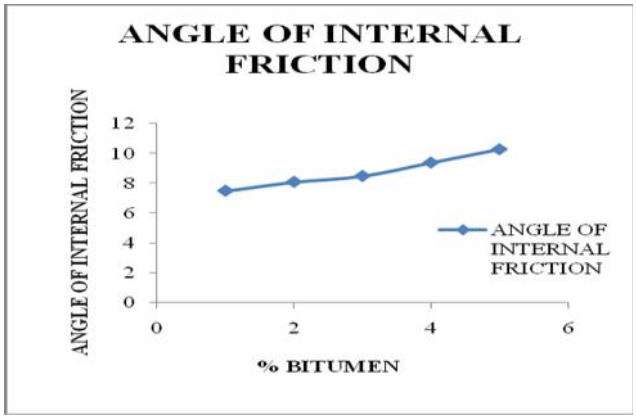

Fig 6.12 Plot showing the Variation in angle of internal frictionwith different % of bitumen

It can be inferred from the above results the optimum content of bitumen with 0.75% coir fibremixed with marine clay is 3%.

5.4 EFFECT OF (CURING) ON SAMPLES PREPARED WITH 3% BITUMEN + 0.75% COIR FIBRE AS ADDITIONOF MARINE CLAY

From the above results It is observed that samples prepared with 3% BITUMEN + 0.75% COIR FIBRE as addition of marine clay and the graph shows increment of UCS and CBR values with increment of curing periods.

Finally from the above discussions, it is clear that there is improvement in the behavior of Weak Marine soil stabilized with BITUMEN + COIR FIBRE. It is evident that the addition of COIR FIBRE to the virgin Marine soil showed an improvement in plasticity, compaction and strength properties to some extent and on further blending it with BITUMEN, 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 BITUMEN and COIR FIBRE in the weak marine soil has reduced the plastic nature of the clay. It can be summarized that the materials BITUMEN and COIR FIBRE 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.

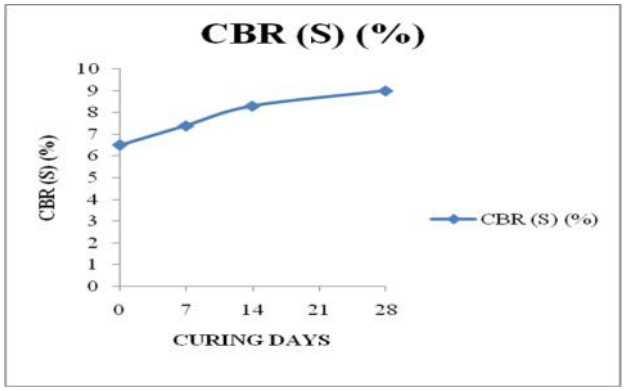

Fig 6.11 Plot showing the Variation in CBR at different curing periods

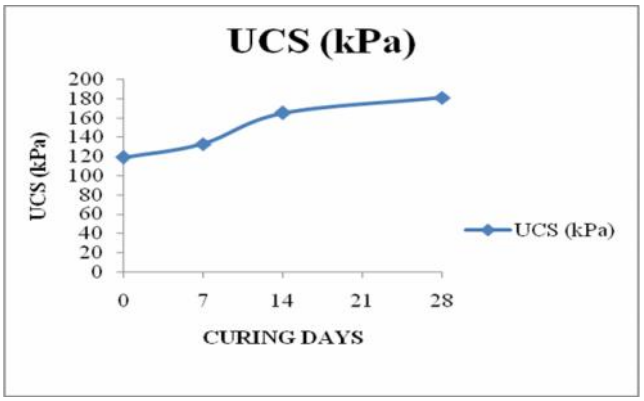

Fig 6.12 Plot showing the Variation in UCS at different curing periods

VI. 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 noticed that when the Marine Clay was treated with 0.75% coir fiber and 0.75% Coir Fibre+3% Bitumen the liquidity limit and plasticity index of Marine Clay has been decreased by 19.39%, 41.25% and 40.57%, 79.93 respectively when Compared with untreated Marine Clay.
- It was noticed that when the Marine Clay was treated with 0.75% coir fiber and 0.75% Coir Fibre+3% Bitumen Dust the free swell is decreased by 38.98% and 73.58% respectively when compared with untreated Marine Clay.
- It was noticed that when the Marine Clay was treated with 0.75% coir fiber and 0.75% Coir Fibre+3% Bitumen the CBR values are increased by 255.981%

and 507.28% respectively when compared with untreated Marine Clay.

- It was noticed that when the Marine Clay was treated with 0.75% coir fiber and 0.75% Coir Fibre+3% Bitumen the UCC values are increased by 111.92% and 152.67% respectively when compared with untreated Marine Clay.
- It is evident that the addition of Coir Fibre and Bitumen to the virgin Marine soil showed an improvement in properties of Marine Clay.

Finally it can be summarized that the materials Coir Fibre and Bitumen 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.The following conclusions are made based on the laboratory experiments carried out in this investigation.

REFERENCES

[1] Chu,J, Myint Win Bo, M.F.Chang and V. Choa (2002), Consolidation and Permeability Properties of Singapore Marine Clay. Journal of Geotechnical and Geo environmental Engineering, Vol.128, No.9, September 2002, pp.726-732.

[2] Clare, K.E. and Cruchley, A.E (1957), Laboratory experiments in the stabilization of clays with hydrated PHOSPHO GYPSUM (PG), Geotechnique, Vol. 7, 1957, pp. 97-111.

[3] Felt, E.J (1955), Factors Influencing Physical Properties of Soil-Phospho Gypsum (PG) Mixtures, Portland Phospho Gypsum (PG) Association, Skokie, Illinois, DX016, 1955.

[4] Gopal Ranjan and A.S. R. Rao (2006), Basic and Applied Soil Mechanics, New Age International Publishers.

[5] Koteswara Rao, D (2006), The performance studies on Geo-grid as reinforcemnt in the flexible pavement construction, IGC-2006, pp 657-660.

[6] Koteswara Rao, D (2006), the efficacy of Granulated Blast Furnace Slag- Fly ash mix as a fill material on soft soil beds for the foundations, CES-2006, Osmania University, Hyderabad.

[7] S. A. Naeini and s. M. Sadjadi ,(2008) ," effect of waste polymer materials on shear strength of Unsaturated Clays", EJGE Journal, Vol 13, Bund k,(1-12).

[8] Yetimoglu, T., Inanir, M., Inanir, O.E., 2005. A study on bearing capacity of randomly distributed fibre-reinforced sand fills overlying soft clay. Geotextiles and Geomembranes 23 (2), 174–183.

[9] Chaosheng Tang, Bin Shi, Wei Gao, Fengjun Chen, Yi Cai, 2006. Strength and mechanical behavior of short polypropylene fibre reinforced and cement stabilized clayey soil. Geotextiles and Geomembranes 25 (2007) 194–202.

[10] Mahmood R. Abdi, Ali Parsapajouh, and Mohammad A. Arjomand,(2008)," Effects of Random Fibre Inclusion on Consolidation, Hydraulic Conductivity, Swelling, Shrinkage Limit and Desiccation Cracking of Clays", International Journal of Civil Engineering, Vol. 6, No. 4, (284-292)

[11] Consoli, N. C., Prietto, P. D. M. and Ulbrich, L. A. (1999). ''The behavior of a fiber-reinforced cemented soil.'' Ground Improvement, London, 3(1), 21–30. IS 2720 – part (xiii) 1980-87

[12] The need for soil stabilization, April 9, 2011 by Ana [online] Available at :< http://www.contracostalandscaping.com/the-need-for-soil-stabilization. Methods of soil stabilization, December 24, 2010 [online] Available at http://www.engineeringtraining.tpub.com/14070/css/14070_424.html

[13] Prof. Krishna Reddy, UIC, 2008, Engineering Properties of Soils Based on Laboratory Testing. Understanding the Basics of Soil Stabilization: An Overview of Material and Techniques [online] Available at : http://www.cat.com.Nataraj, M. S. &McManis, K. L. (1997). Strength and deformation properties of soils reinforced with fibrillated fibres. Geosynthetics International, 4, No. 1, 65–79.

[14] Kumar, R., Kanaujia, V. K. & Chandra, D. (1999). Engineering behavior of fibre-reinforced pond ash and silty sand. Geosynthetics International, 6, No. 6, 509–518.

[15] Kaniraj.S.R and Vasant G H. (2001), Behavior of cementstabilizedfibre-reinforced fly ash soil mixtures, Jou. OfGeotechnica land Geo-environmental Engineering, Vol.127, No.7,574-584.