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A Modern and Experimental Study on Stabilization of Marine Clay by using Bitumen and Coir Fibre for Foundation

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Abstract: Here, in this project, marine soil stabilization has been done with the help of randomly distributed polypropylene fibers obtained from waste materials. The improvement in the shear strength parameters has been stressed upon and comparative studies have been carried out using different methods of shear resistance measurement. Reinforcement of soils with natural coir is potentially an effective technique for increasing soil strength. 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. 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. The present investigation aims to explore the performance of different percentages of bitumen and coir fiber material reinforced with marine clay.
Keywords: Bitumen, Coir Fiber, Marine Clay, Shear Strength

I. INTRODUCTION

The marine clays are highly compressible soft clay sand also it exhibits moderate swelling when comes in contact with moisture. This behavior is due to the presence of clay minerals with expanding lattice structure. The marine clay is very hard when it is dry but loses its strength on wetting. For any land-based structure, the foundation is very important and has to be strong to support the entire structure. In order for the foundation to be strong, the soil around it plays a very critical role. So, to work with soils, we need to have proper knowledge about their properties and factors which affect their behavior. The process of soil stabilization helps to achieve the required properties in a soil needed for the construction work. A land based Structure of any type is only as strong as its foundation. For that reason, soil is a critical element influencing the success of a construction project. Soil is either part of the foundation or one of the raw materials used in the construction process. Therefore, understanding the engineering properties of soil is critical to obtain strength and economic performance. Soil stabilization is the process of maximizing the suitability of soil for a given construction purpose.

Reinforcement of soils with natural coir is potentially an effective technique for increasing soil strength. In recent year, this technique has been suggested for a variety of geotechnical applications ranging from retaining structures and earth embankments to sub grade stabilization beneath footing and pavements. Research of different reinforcement and materials has been conducted by several investigations. However, the amount of information available on randomly oriented fiber and bitumen reinforcement is still limited.

II. NEED OF PRESENT STUDY

Soil properties vary a great deal and construction of structures depends a lot on the bearing capacity of the soil, hence, we need to stabilize the soil which makes it easier to predict the load bearing capacity of the soil and even improve the load bearing capacity. The gradation of the soil is also a very important property to keep in mind while working with soils. The soils may be well-graded which is desirable as it has less number of voids or uniformly graded which though sounds stable but has more voids. Thus, it is better to mix different types of soils together to improve the soil strength properties. It is very expensive to replace the inferior soil entirely soil and hence, soil stabilization is the thing to look for in these cases

III. OBJECTIVES OF PRESENT STUDY

The objectives of the present study are as follows.

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

IV. LABORATORY EXPERIMENTATION

A. *Marine Clay*

The marine clay used as the foundation soil in this study is of typical soft clay. The marine clay was collected at a depth of 0.40 m to 1.00 m from the existing ground level.

Table 4.1: Physical properties of marine clay

S.NO	Property		Value
1	Gravel (%)		0
2	Sand (%)		11
3	Fines	Silt (%)	19
		Clay (%)	70
4	Liquid Limit (%)		74.52
5	Plastic Limit (%)		29.12
6	Plastic Index (%)		45.40
7	Soil Classification		CH
8	Specific Gravity (G)		2.47
9	Free Swell (%)		75
10	Optimum Moisture Content (%)		30.34
11	Maximum Dry Density (g/cc)		1.403
12	Cohesion (t/m^2)		12
13	Angle of Internal Friction (^{0})		3.5
14	CBR Value (%)		1.07

B. *Physical Properties of Coir Fiber*

Coir fiber is made-up of a natural fiber and reinforcing material. This is in spite of the fact that strong fibres like coir which have very high lignin content can be effectively use of as reinforcing material. Coir fibre density is 1.40(g/cc) and diameter in 0.1mm to 1.5mm and length 6.8 inches. The swelling condition suggested diameter of the coir fibre and swelling in water 5%.

C. *Chemical Properties coir fiber*

Chemical properties of coir fiber are mixing some amount of ash. The chemicals are lignin, cellulose, hemi-cellulose, pectin's and related compound, water soluble and ash.

Table 4.2: 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 (%)	03.00
5	Water soluble (%)	05.25
6	Ash (%)	02.22

D. *Properties of Bitumen*

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.

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E. Tests conducted

The soil was initially air dried prior to the testing. The tests were conducted in the laboratory on the marine clay to study the behavior of the marine clay, when it was untreated and also treated with fly ash and quarry dust for the model foundation soil bed.

1) Atterberg limits
2) Compaction Test
3) Free swell (FS)
4) CBR Test
5) Tri-axial Test
6) Unconfined Compression Test
7) Specific gravity test
8) Static Plate Load Test

V. RESULTS AND DISCUSSIONS

Table 5.1: Compaction Test Results for Untreated Marine Clay

Mix Proportion	Water Content (%)	Dry Density (g/cc)
Marine Clay	29.23	1.337
	32.45	1.345
	35.34	1.373
	37.12	1.354
	39.12	1.326

A. Compaction Test Results for Marine Clay Treated with Percentage Variation of Coir Fiber

Table 5.2 presents the OMC and MDD values of the marine clay treated with % variation of coir fiber.

Table5.2: Compaction properties of marine clay treated with percentage variation of coir fiber

Mix Proportion	OMC (%)	MDD (g/cc)
100% Marine clay+0% coir fiber	35.34	1.373
99.75% Marine clay +0.25%coir fiber	32.37	1.408
99.5% Marine clay +0.5%coir fiber	30.77	1.435
99.25% Marine clay +0.75%coir fiber	27.34	1.482
99% Marineclay+1.0% coir fiber	24.34	1.475

1) CBR, UCC and Tri-Axial Test Results of Untreated Marine Clay and Marine Clay Treated with Various Percentages of Coir Fiber

Table 5.3 CBR, UCC and Tri-Axial Test Results of Untreated Marine Clay and Marine Clay Treated with Various Percentages of Coir Fiber

Mix proportion	% Variation of Coir Fiber	Soaked CBR	UCC (kN/m^2)	Cohesion 'c' (kN/m^2)	Angle of internal Friction(φ)
Marine clay	0	0.895	69.4	12	3.5
99.75% Marine clay	0.25	3.137	79.71	10.5	4.2
99.5% Marine clay	0.5	3.361	94.9	8.43	5.2
99.25% Marine clay	0.75	3.809	128	7.85	5.8
99% Marine clay	1.0	3.495	118	5.67	6.7

2) Compaction Properties of 0.75% coir fiber treated marine clay with various percentages of bitumen.

Table 5.4 Compaction Properties of 0.75% coir fiber treated marine clay with various percentages of bitumen.

Mix proportion	OMC (%)	MDD(g/cc)
0.75% Coir Fiber treated Marine clay with 1%Bitumen	25.40	1.495
0.75% Coir Fiber treated Marine clay with 2%Bitumen	25.90	1.509
0.75% Coir Fiber treated Marine clay with 3%Bitumen	23.23	1.514
0.75% Coir Fiber treated Marine clay with 4%Bitumen	24.79	1.48
0.75% Coir Fiber treated Marine clay with 5%Bitumen	26.76	1.465

3) CBR, UCC, Tri-Axial values of 0.75% coir fiber treated marine clay with various percentage of bitumen

Table 5.5 CBR, UCC, Tri-Axial values of 0.75% coir fiber treated marine clay with various percentage of bitumen

Mix proportion	%variation of Bitumen	Soaked CBR	UCC (kN/m^2)	Cohesion 'c' (kN/m^2)	Angle of Internal Friction(φ)
0.75% Coir Fiber treated Marine clay with Bitumen	1	5.14	127.2	4.8	7.5
0.75% Coir Fiber treated Marine clay with Bitumen	2	5.60	135	4.1	8.1
0.75% Coir Fiber treated Marine clay with Bitumen	3	6.498	152.6	3.67	8.5
0.75% Coir Fiber treated Marine clay with Bitumen	4	4.48	148	2.8	9.4
0.75% Coir Fiber treated Marine clay with Bitumen	5	4.70	139	2.06	10.3

4) Properties Of Untreated And Treated Marine Clay

Table 5.6 presents the properties of untreated and treated marine clay with an optimum of 0.75% Coir Fiber and 3% Bitumen.

Table 5.6: Properties of Untreated and Treated Marine Clay

S.No	Property	Untreated Marine Clay	0.75% Coir Fiber Treated Marine Clay	0.75% Coir Fiber + 3%Bitumen treated MC
1.	Atterberg limits Liquid limit (%) Plastic limit (%) Plasticity index (%)	 74.52 29.12 45.40	 60.07 33.09 26.98	 43.78 34.67 9.11
2.	Compaction properties Optimum Moisture Content (%) Maximum Dry Density (g/cc)	 30.34 1.403	 27.42 1.482	 20.56 1.514
3	Specific Gravity (G)	2.47	2.57	2.62
4.	C.B.R (%)	1.07	3.809	6.498
5.	Free swell (%)	75	45.76	27.85
6	Shear Strength Parameters Cohesion (t/m^2) Angle of internal friction (^{0})	 12.0 3.5	 7.85 5.8	 3.67 8.5
7	UCC(kN/m^2)	69.4	128.8	152.6

5) Laboratory Static Plate Load Test Results of Untreated and Treated Marine Clay Model Foundation Bed at OMC.

Table 5.7 Laboratory Static Plate Load Test Results of Untreated and Treated Marine Clay Model Foundation Bed at OMC.

S.No	Foundation Bed	Cushion	Load Bearing Capacity	Settlement (mm)
			OMC	OMC
1	Marine Clay	----	213.28	3.78
2	Untreated marine clay	Gravel	610.920	2.67
3	Treated marine clay (0.75%CoirFibre+3% Bitumen)	Gravel	885.834	2.13
4	Treated marine clay (0.75% Coir Fibre+3% Bitumen) and Geo-textile provided as reinforcement & separator between Foundation Bed and Gravel Cushion.	Gravel	1481.48	1.54

VI. CONCLUSIONS

1) 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.

2) 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.

3) 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.

4) 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.

5) It was noticed from laboratory plate load test that the total deformations at ultimate load carrying capacity of treated model foundation bed has decreased by 45.0% at OMC when compared to the untreated Marine Clay.

6) It was noticed from laboratory plate load test that ultimate load bearing capacity of the treated Marine Clay has increased by 142.49% when compared to the un treated Marine Clay at OMC when compared to the untreated Marine Clay.

7) It was noticed that when the Marine Clay was treated with 0.75% coir fibre 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.

8) It was noticed that when the Marine Clay was treated with 0.75% coir fibre 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.

9) It was noticed from laboratory plate load test that the total deformations at ultimate load carrying capacity of treated model foundation bed has decreased by 45.0% at OMC when compared to the untreated Marine Clay.

10) It was noticed from laboratory plate load test that ultimate load bearing capacity of the treated Marine Clay has increased by 142.49% when compared to the un treated Marine Clay at OMC when compared to the untreated Marine Clay.

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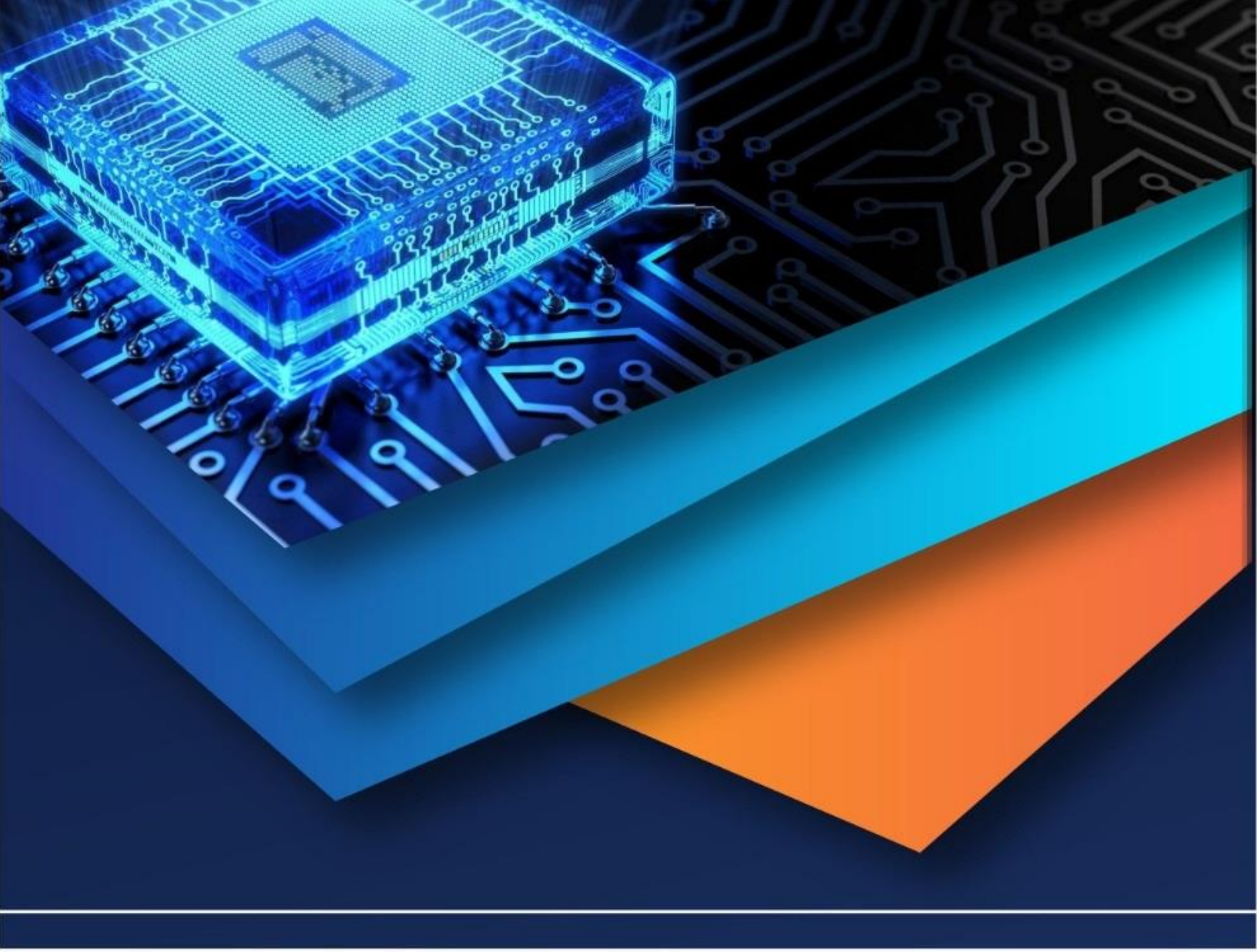

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