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Comparative Study On Soil Stabilisation with and without Coconut Coir

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Abstract: *To make use of locally available soils, soil strength should be increased because every time it is not possible to find required or specified strength in locally available soils. Soil strength can be increased by adding stabilizing agents like lime, cement, fly ash, fibre etc. Use of natural fibre in civil engineering for improving soil properties is advantageous because they are cheap, locally available, biodegradable and eco-friendly. The coir fibre reinforcement causes significant improvement in bearing capacity and shear strength and other engineering properties of soil. The experimental study is conducted on locally available soil reinforcement with coconut coir fibre. Soil sample is prepared at its maximum dry density corresponding to its optimum moisture content (OMC). The percentage of coir fibre by dry weight of soil is taken 0%, 0.25%. The index properties of soil tests is conducted and shear strength of soil is compared before and after adding of coir fibre to the soil*

Keywords: Soil Stabilization, Coir fibre, OMC, Shear Strength, Index properties

I. INTRODUCTION

Soil stabilization using natural fibers is an environmentally sustainable method that enhances the physical and mechanical properties of soil to improve its load-bearing capacity, durability, and overall performance. This technique involves the incorporation of biodegradable and renewable fibers such as coir, jute, hemp, flax, and sisal into soil to strengthen and stabilize it for various engineering and construction applications. Traditional soil stabilization methods often rely on chemical additives or synthetic materials, which can be expensive, environmentally harmful, and less sustainable in the long term. In contrast, natural fibers are abundantly available, low-cost, and biodegradable, making them an ideal choice for eco-friendly construction practices. These fibers interact with soil particles to increase tensile strength, reduce settlement, and control erosion. The presence of natural fibers helps to bind the soil together, reduce shrinkage cracks, and improve resistance against external loads. This is particularly useful in rural and remote areas where advanced construction materials and techniques are less accessible.

II. OBJECTIVE

- To improve the shear strength and load-bearing capacity of soil by reinforcing it with coconut coir fibers.
- To reduce soil erosion through enhanced inter-particle bonding provided by the coir fibers.
- To minimize settlement and shrinkage in soil structures by increasing tensile strength and flexibility.
- To enhance soil durability and performance in various environmental conditions.
- To utilize agricultural waste (coconut husk) effectively, promoting sustainable and eco-friendly construction practices.
- To provide a low-cost and locally available alternative to chemical soil stabilizers.
- To increase the stability of slopes, embankments, and road subgrades using biodegradable natural reinforcement.
- To support green engineering solutions by reducing reliance on non-renewable and synthetic materials.
- To explore the potential of coconut coir in geotechnical applications through research and field implementation.

- To contribute to sustainable development goals by integrating natural resources in infrastructure development.

III. METHODOLOGY

Collection of Materials
- Soil: Collect representative soil samples from the site for testing.
- Coconut Coir: Obtain coir fiber in dry form. Clean and sun-dry the coir if necessary.

Preparation of Soil-Coconut Coir Mixtures
- Mix soil with varying percentages of coconut coir of 0%, 0.25%.
- Ensure uniform mixing of coir in soil.

Compaction Test on Treated Sample.
- Perform the Proctor Compaction Test on each soil-coir mix.
- Determine how the addition of coir affects the OMC and MDD.

Comparative Moisture Content
- Repeat Moisture Content tests on the coir-treated soil samples. Note the changes in plasticity and moisture retention characteristics.

IV. TEST CONDUCTED

SPECIFIC GRAVITY

Specific gravity of a substance denotes the number of times that substance is heavier than water. In simpler words we can define it as the ratio between the mass of any substance of a definite volume divided by mass of equal volume of water. In case of soils, specific gravity is the number of times the soil solids are heavier than equal volume of water. Different types of soil have different specific gravities, general range for specific gravity of soils.
- Mass of Pycnometer = 161g
- Mass of Pycnometer + dry soil = 361g
- Mass of Pycnometer + soil + water = 889g
- Mass of Pycnometer + water = 759g
- Specific gravity of soil solids = 2.81

MOISTURE CONTENT

Water content or moisture content is the quantity of water contained in a material, such as soil, rock, ceramics, crops . Water content is used in a wide range of scientific and technical areas, and is expressed as a ratio. According to IS2720(part 2) it ranges from 0 to the value of materials porosity of saturation. It can be given on a volumetric or mass (gravimetric) basis. Can.no G20
- Weight of can with lid = 15.05g
- Weight of can with lid +Wet soil = 35.41g
- Weight of can with lid +Dry soil = 35.13g
- Weight of water = 0.28g
- Weight of Dry soil = 20.08
- Moisture Content = 1.39%

ATTERBERG LIMITS

1) Plastic Limit:

This limit lies between the plastic and semi-solid state of the soil. It is determined by rolling out a thread of the soil on a flat surface which is non-porous. It is the minimum water content at which the soil just begins to crumble while rolling into a thread of approximately 3mm diameter. Plastic limit is denoted by wP.

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Table 4.1 ATTERBERG LIMIT

	LIQUID					PLASTIC		
Test No.	1	2	3	4	5	1	2	3
No. of blows	9	16	20	22	28			
Can No.	G20	G25	G10	G27	G19	G8	G12	G7
Mass of can (g)	15.06	17.81	17.05	20.77	15.96	15.86	15.35	18.11
Mass of can + Wet soil (g)	27.82	28.1	26.71	32.44	27.73	25.42	25.28	28.38
Mass of can + Dry soil (g)	25.24	26.04	24.79	30.18	25.49	24.34	24.22	27.23
Water Content (%)	25.63	25.03	24.8	24.12	23.5	12.73	11.95	12.6

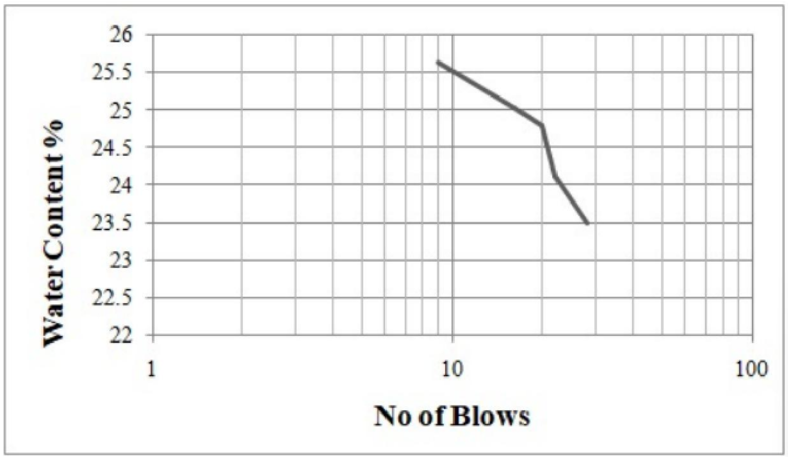

FIG 4.1 ATTERBERG LIMIT

TEST CONDUCTED ON SOIL WITHOUR COIR

STANDARD PROCTOR COMPACTION TEST

A laboratory test called the Standard Proctor Compaction Test is used to find the soil's ideal moisture content and maximum dry density. It entails using a 2.5 kg rammer dropped from a height of 30 cm to compact soil at varying moisture levels in a standard mould. The findings aid in determining the ideal compaction level, which is necessary for the stability of embankments, foundations, and other soil structures during construction.

Observation and Calculation:

- Diameter of mould, d (cm) = 10cm
- Height of mould, h(cm) = 13cm
- Volume of mould, v(cm3)= 1021.02cc
- Mass of mould, w(g)= 1985g
- Weight of rammer (kg)= 2.65 kg
- No. of layers = 3 and No. of blows per layer = 25

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S.NO	Trial 1	Trail 2	Trail 3
Mass of mould +compacted soil (g)	3919	4052	4178
Mass of compacted soil (g)	1934	2065	2193
Bulk density ()	1.89	2.02	2.14
Mass of container(g)	17.81	15.86	17.06
Mass of container + Wet soil (g)	41.35	44.19	41.49
Mass of can + Dry soil (g)	39.91	42.05	39.31
Mass of water (g)	1.44	2.14	2.18
Mass of dry soil (g)	22.1	26.19	22.25
Water content (%)	6.51	8.17	9.79
Dry density 1.77 1.86 1.94	1.77	1.86	1.94
Dry density at 100% saturation	2.36	2.37	2.19

Table 4.2 COMPACTION WITHOUT COIR FIBRE

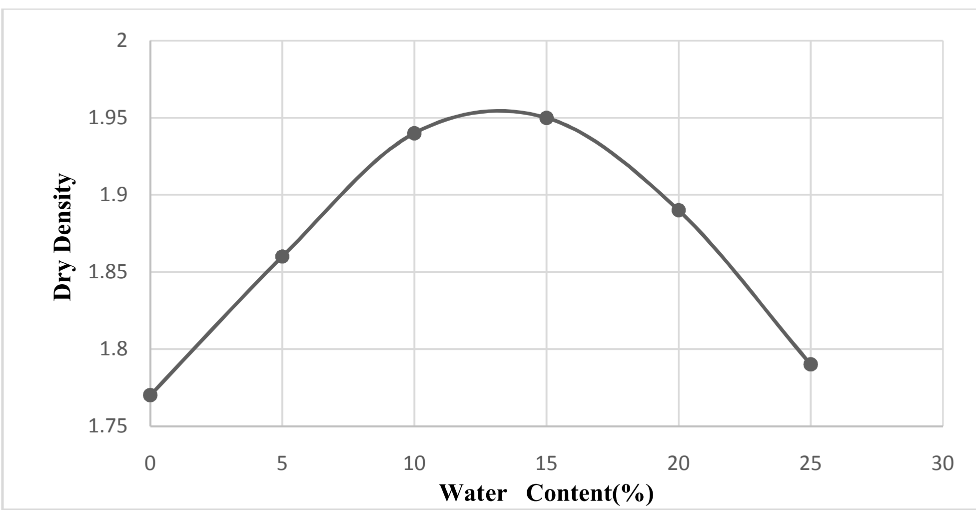

FIG 4.2 COMPACTION TEST

- Optimum moisture content = 11%
- Maximum dry density = 1.95g/cc

DIRECT SHEAR TEST

In soil mechanics, a laboratory test called the Direct Shear Test is used to measure a soil sample's shear strength. This test involves placing a soil sample in a shear box, pushing one half of the box horizontally until the soil fails along a predefined plane, and then subjecting the soil to a constant normal load. The test determines the cohesion and angle of internal friction of the soil by measuring the maximum shear force necessary to cause failure. In geotechnical engineering, this test is frequently used to design retaining walls, slopes, and foundations.

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TABLE 4.3 DIRECT SHEAR TEST

Horizontal dial gauge reading (div)	Horizontal dispalcement (mm)	Shear strain	Load dial reading(div)			Horizontal shear force (N)			Shear stress (N/mm2)		
			1kg	2kg	3kg	1kg	2kg	3kg	1kg	2kg	3kg
50	0.5	0.0083	17	31	53	43.1	78.6	134.4	0.012	0.022	0.034
100	1	0.01667	30	46	77	76.1	116.6	195.2	0.021	0.032	0.055
150	1.5	0.025	39	58	99	98.9	147.1	250.9	0.027	0.041	0.070
200	2	0.0334	50	72	105	126.8	182.5	266.2	0.035	0.051	0.074
250	2.5	0.0416	57	85	115	144.5	215.5	291.5	0.040	0.056	0.081
300	3	0.05	62	95	131	157.2	240.8	332.1	0.044	0.067	0.092
400	4	0.066	72	112	158	182.5	283.9	400.5	0.051	0.079	0.111
500	5	0.0833	81	126	184	205.3	319.4	466.4	0.057	0.089	0.129
700	7	0.1167	89	149	215	225.6	377.7	545.02	0.063	0.105	0.151
900	9	0.15	96	161	231	243.4	408.1	585.5	0.068	0.113	0.163
1100	11	0.1834	95	160	233	240.8	405.6	590.65	0.067	0.114	0.164
1300	13	0.2166	94	159	227	238.1	403.1	580.5	0.066	0.112	0.161

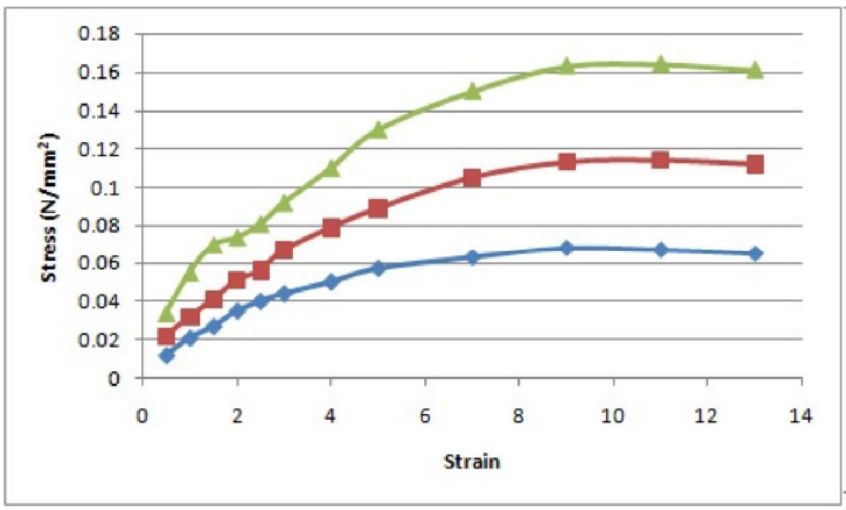

FIG 4.3 GRAPH FOR DIRECT SHEAR TEST

TEST CONDUCTED ON SOIL WITH COIR

STANDARD PROCTOR COMPACTION TEST

A laboratory test called the Standard Proctor Compaction Test is used to find the soil's ideal moisture content and maximum dry density. It entails using a 2.5 kg rammer dropped from a height of 30 cm to compact soil at varying moisture levels in a standard mould. The findings aid in determining the ideal compaction level, which is necessary for the stability of embankments, foundations, and other soil structures during construction.

Observation and Calculation:

- Type of compaction : Standard proctor test
- Diameter of mould, d (cm) = 10cm
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- Mass of mould, w(g)= 1985g
- Weight of rammer (kg)= 2.65 kg
- No. of layers = 3
- No. of blows per layer = 25


Fig.1 RED SOIL


Fig.2 COCONUT COIR

	8%	10%	12%	14%	16%	18%
Test No	1	2	3	4	5	6
Mass of mould+compacted soil(g)	3739	3919	3971	4143	4204	4167
Mass of comp soil(W1)	1754	1934	1986	2158	2219	2182
Bulk density =W1/V	1.717	1.894	1.945	2.11	2.173	2.13
Can no	G8	G10	G18	G24	G19	G16
Mass of can	15.86	17.06	16.3	18.4	12.8	11.3
Mass of can+wet soil	31.8	32.6	31.9	33.5	28.8	34.8
Mass of can +dry soil	31.1	31.8	30.7	32.1	27.0	32.3
Mass of water	0.7	0.8	1.2	1.4	1.8	1.5
Mass of dry soil	15.24	14.74	14.4	13.7	14.2	14
Water content(%)	4.59	5.42	8.33	10.21	10.81	10.7
d=/1+w	1.64	1.79	1.8	1.93	2.01	1.91
Dry density at 100% saturation	2.48	2.43	2.27	2.17	2.06	1.98

TABLE 4.4 COMPACTION WITH COIR FIBRE (0.25%)


FIG.3 RED SOIL WITH COIR


FIG.4 COMPACTION TEST

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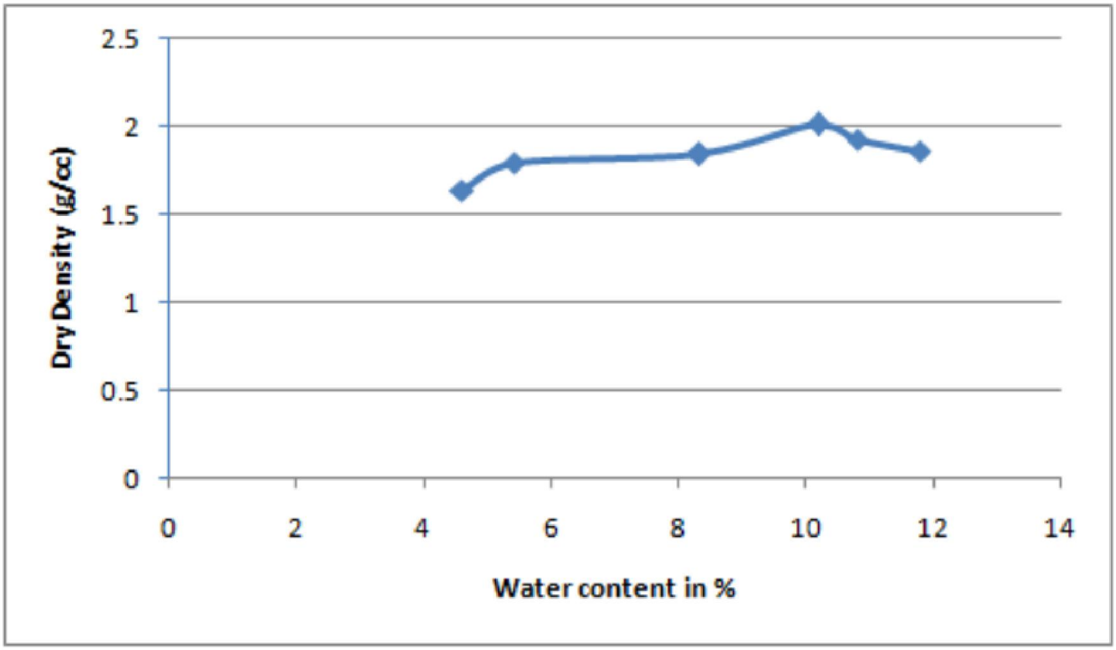

FIG 4.3 GRAPH FOR COMPACTION

DIRECT SHEAR TEST WITH 0.25% COIR

In soil mechanics, a laboratory test called the Direct Shear Test is used to measure a soil sample's shear strength. This test involves placing a soil sample in a shear box, pushing one half of the box horizontally until the soil fails along a predefined plane, and then subjecting the soil to a constant normal load. The test determines the cohesion and angle of internal friction of the soil by measuring the maximum shear force necessary to cause failure. In geotechnical engineering, this test is frequently used to design retaining walls, slopes, and foundations.

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			1kg	2kg	3kg	1kg	2kg	3kg	1kg	2kg	3kg
50	0.5	0.0083	6	10	65	15.21	25.35	164.7	0.004	0.0074	0.045
100	1	0.01667	9	37	102	22.82	93.8	258.6	0.006	0.026	0.071
150	1.5	0.025	19	62	142	48.17	157.2	359.9	0.013	0.043	0.09
200	2	0.0334	45	97	170	114.1	245.9	430.9	0.032	0.068	0.12
250	2.5	0.0416	64	132	196	162.2	334.6	496.8	0.045	0.092	0.13
300	3	0.05	76	160	216	192.7	405.6	547.5	0.053	0.112	0.15
400	4	0.066	84	194	242	212.9	491.8	613.4	0.059	0.136	0.17
500	5	0.0833	79	206	246	200.3	522.2	623.6	0.055	0.145	0.173
700	7	0.1167	71	200	237	179.9	507	600.8	0.049	0.14	0.168
900	9	0.15		192	229		486.7	580.5		0.135	0.161

Table 4.5 Direct Shear Test with Coir Fibre (0.25%)

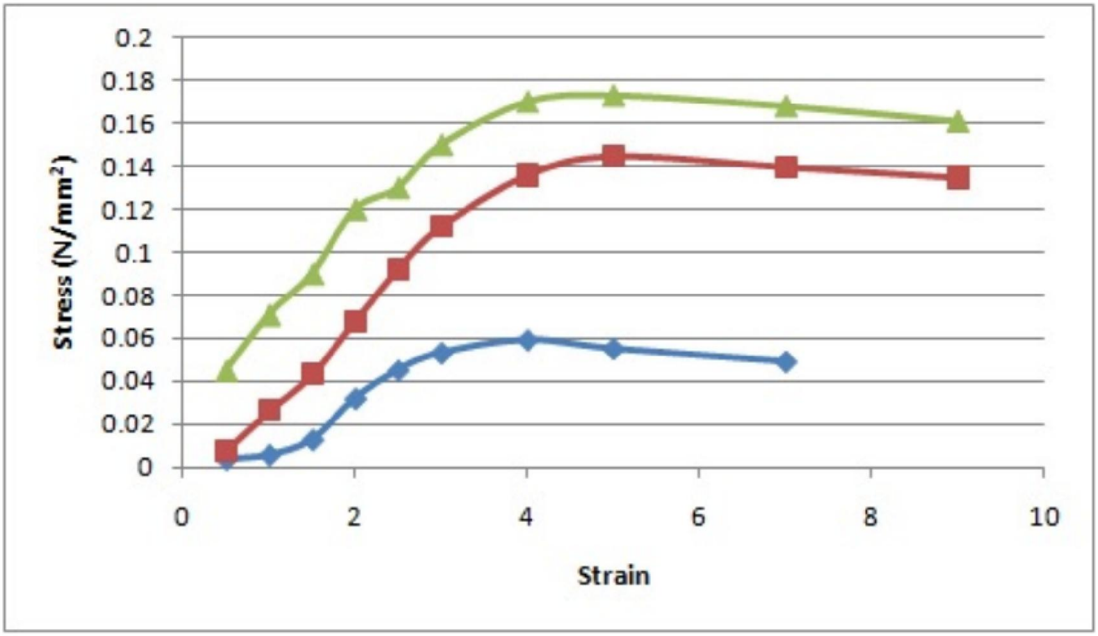

FIG 4.4 GRAPH FOR DIRECT SHEAR TEST

V. CONCLUSION

The addition of coir fiber has significantly improved engineering properties of soil:

Addition of 0.25% coir fiber increased MDD by 3% and decreased OMC by 7%. Hence greater density hasbeenachieved at minimum moisture content.

Addition of 0.25% coir fiber increase shear strength by 5%.

Thus the use of coir as a stabilizing agent has converted the otherwise unsuitable soils to even better soil fiber composite which has varied applications in rural roads, embankments, sheet pile walls, dykes, canal diversion works, temporary check dams etc.

Adopting sustainable, economical and ecofriendly but effective techniques to improve soil properties are the need of the hour. Hence coir fiber turns out to be an effective stabilizing agent for red soil especially in a country like India as it not only adds to the economic development of the country but also satisfies the needs of the rural areas in a sustainable manner.

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