

Comparative Study of Strength Parameters of Clay by Inclusion of Untreated and Treated Coir Fibres

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Abstract— Reinforcement to the soil imparts greater strength to the soil. The reinforcement used the natural fibre, coir. India is one of the largest leading producers of coir, it can be used as a reinforcement for weak soil such as clay. One of the major limitation is that coir fibre is degradable and hence the durability of coir fiber can be extended by treating it with reagents like sodium hydroxide and dust cleaning reagent. A series of compaction tests were conducted and the optimum moisture content were obtained and from the optimum moisture content obtained unconfined compression tests, CBR tests were conducted and an improvement in the strength parameters was studied. SEM studies were conducted on coir fibre.

Keywords— Coir, sodium hydroxide, dust cleaning reagent, clay

I. INTRODUCTION

Soil has been used as a construction material from past. Weak soils are poor in mechanical properties, it has been putting challenges to civil engineers. Addition of fiber in soil improves the overall engineering performance of soil. Fibre reinforced soil is effective in all types of soils. Of all the natural fibers coir is having one of the highest tensile strength and retains this property even in wet condition. Studies have also shown that durability of natural fibre can be improved using coating of fibre with phenol, bitumen, kerosene. The primary purpose of reinforcing a soil mass is to improve its stability by increasing its bearing capacity, and by reducing settlement and lateral deformation. The random inclusion of various types of fibers in which the fibers act to interlock soil particles. Their main advantage is that they are locally available and are of low cost.

II. MATERIALS AND METHODOLOGY

A. Materials

The clay was collected from English Indian Clay Limited, Kochuveli, Trivandrum. The clay collected was kaolinite. The coir was collected from coir board, Pathirapally, Alappuzha. The reagents used were Sodium hydroxide and dust cleaning reagent. Sodium hydroxide was purchased from Chemical laboratory shop, Trivandrum. Dust cleaning reagent was purchased from a local market Bangalore.

B. Methodology

The initial properties of clay including atterberg limits, specific gravity were obtained. Hydrometer analysis was conducted to find the percentage of sand, silt and clay. Using optimum moisture content obtained from compaction test, unconfined compression tests and CBR tests were conducted. Coir fibers of 20mm length were cut. Fibre percentages were varied from 0.5%, 0.75%, 1%, 1.25%, and 1.5% of dry weight of soil. Optimum percentage of fibre was obtained from unconfined compression test and CBR test. Fibers were treated with 1% NaOH, 2% NaOH, 1% dust cleaning reagent, 2% dust cleaning reagent and submerged in the solution for 24 hours and air dried for 7 days, compaction test were conducted by varying the percentage of fiber 0.5%, 0.75%, 1%, 1.25% and 1.5% UCC test and CBR tests were conducted.

III. RESULTS AND DISCUSSION

The Table 1 shown below shows the properties of the coir collected from Alapuzha

TABLE 1. PROPERTIES OF COIR

Properties	Values
Length(inches)	6-8
Density(g/cc)	1.4
Tenacity (g/tex)	10.0
Breaking elongation	30%
Colour	white

The Table 2 shows the properties of the kaolinite clay collected from the English Indian Clay.

TABLE 2. PROPERTIES OF SOIL

Properties	Values
Liquid limit	34.90%
Plastic limit	23.75%
Plasticity index	11.15%
Unified Soil classification	CL
Shrinkage limit	21%
Maximum dry density	14.2 kN/m ³
Optimum moisture content	30.5%
Specific gravity	2.6
Percentage of sand	4.2%
Percentage of clay	60%
Percentage of silt	35.8%
Undrained shear strength	24.6 kN/m ²
CBR	1.89

The table 3 shown below shows the properties of the Sodium hydroxide.

TABLE 3. PROPERTIES OF SODIUM HYDROXIDE

Properties	Values
Molecular weight	40
Assay	96%
Sulphate	0.05%
Potassium	0.1%
Zinc	0.02%
Chloride	0.01%
Carbonates	2%
Silicates	0.05%

The details were specified in the bottle where sodium hydroxide was purchased.

TABLE 4. PROPERTIES OF DUST CLEANING REAGENT

Properties	Values
Diethanolamine	1.5%
Magnesium oxide	5%
Ethyl alcohol	5%
Dodecyl benzene Sulphonic acid	30%
Sodium lauryl ether sulphate	20%

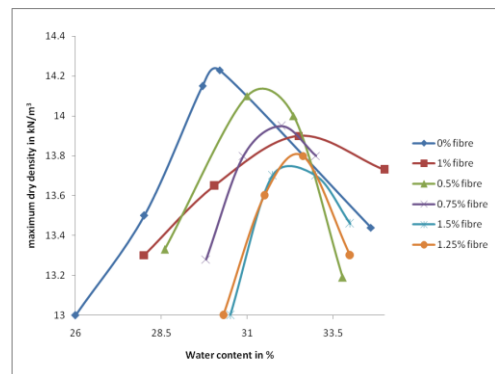


Fig.1. Compaction curves by inclusion of untreated fibres

A. Compaction tests in clay by untreated coir fibre

TABLE 5. COMPACTION RESULTS FOR CLAY BY INCLUSION OF UNTREATED COIR FIBRE

Percentage of fibre (%)	Values	
	Maximum Dry Density(kN/m ³)	Optimum Moisture Content (%)
0.5	14.00	31
0.75	13.95	31.5
1.0	13.9	32.0
1.25	13.8	32.62
1.5	13.7	32.8

B. Variation in Maximum dry density of clay by addition of fibre

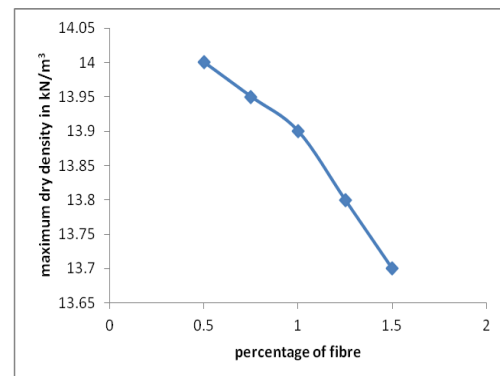


Fig.2. Variation in maximum dry density by addition of coir fibre

The dry density decreases with addition of coir fibre due to lower specific gravity of coir fibre replaces clay of higher specific gravity.

C. Variation in Optimum moisture content of clay by addition of fibre

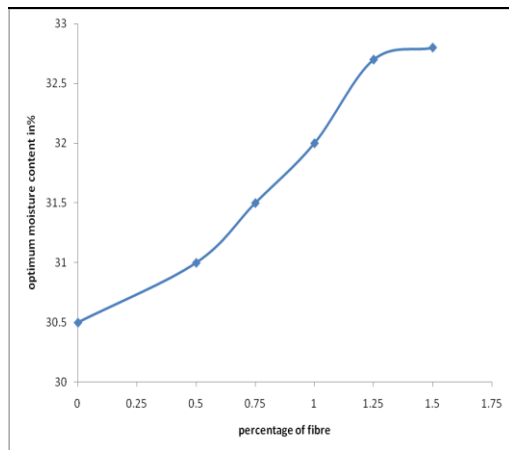


Fig.3. Variation in optimum moisture content by addition of coir fibre

The optimum moisture content increases with addition of coir fibre as coir fibre absorbs more water due to the presence of hemicellulose

D. Variation in shear strength

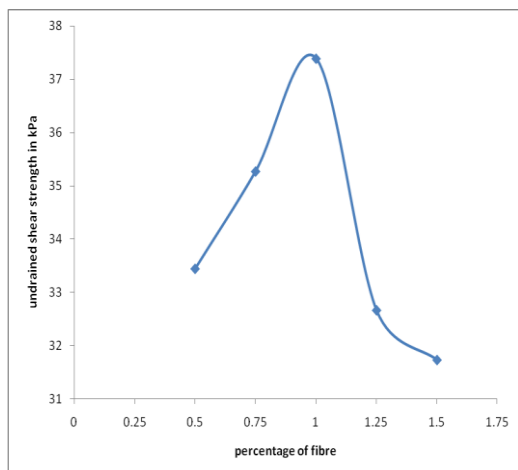


Fig.4. Variation in shear strength by addition of coir fibre

The shear strength was improved by the addition of coir fibre upto 1% and thereafter decreases. This is due to perfect interlocking of coir fibre with the soil upto particular limit and thereafter decreases due to reduced contact area between soil and fibre. The optimum percentage is 1%.

E. Variation in CBR

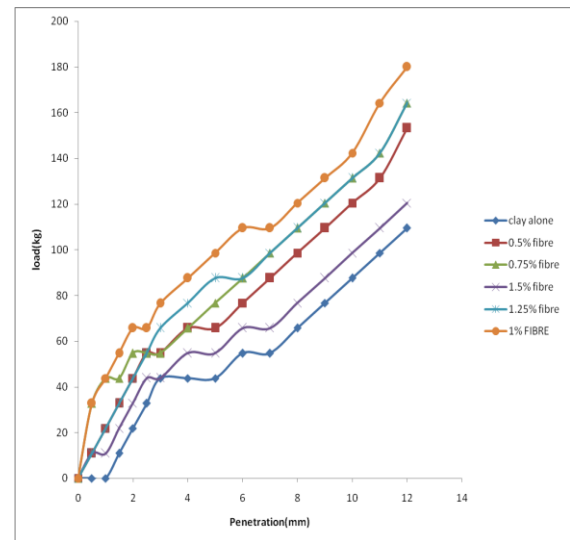


Fig.5. Load penetration graph for clay and clay with coir fibre

TABLE 6. CBR VALUES FOR VARIOUS PERCENTAGE OF FIBRE

Percentage of fibre	Values
	CBR
0	1.89
0.5	3.00
0.75	3.19
1.0	4.7
1.25	4.4
1.5	4.10

The CBR values were improved by addition of fibers upto 1% and thereafter decreases. This is due to reason that randomly oriented discrete fibres in soil mass improves its load deformation behaviour by interacting with the soil particles mechanically through surface friction and also by interlocking. The function of bond or interlock is to transfer the stress from soil to the discrete inclusion by mobilizing the tensile strength of discrete inclusion. Thus, fiber reinforcement works as frictional and tension resistance element.

F. Compaction tests in clay by treated coir fibre

1) 1% NaOH treated fibre in clay

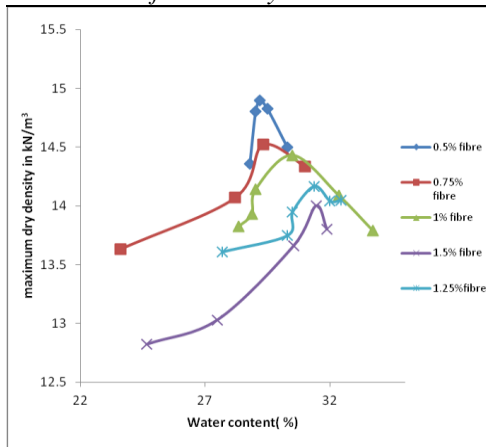


Fig.6. Compaction curves of clay by inclusion of 1% NaOH treated fibre

TABLE 7. COMPACTION RESULT FOR CLAY BY INCLUSION OF 1% SODIUM HYDROXIDE TREATED FIBRE

Percentage of fibre(%)	Values	
	Maximum Dry Density (kN/m ³)	Optimum Moisture Content (%)
0.5	14.9	29.2
0.75	14.52	29.32
1.0	14.43	30.5
1.25	14.16	30.7
1.5	14.10	31.36

2) 2% NaOH treated fibre in clay

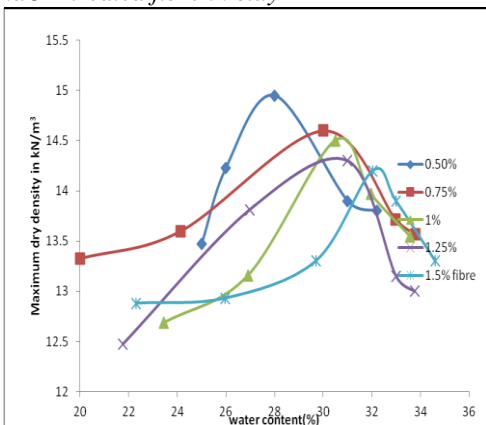


Fig.7. Compaction curves of clay by inclusion of 2% NaOH treated fibre.

TABLE 8. COMPACTION RESULT FOR CLAY BY INCLUSION OF 2% SODIUM HYDROXIDE TREATED FIBRE

Percentage of fibre(%)	Values	
	Maximum Dry Density(kN/m ³)	Optimum Moisture Content (%)
0.5	14.95	28
0.75	14.6	29.0
1.0	14.5	30.25
1.25	14.31	30.5
1.5	14.2	31.0

3) 1% Dust cleaning reagent treated fibre in clay

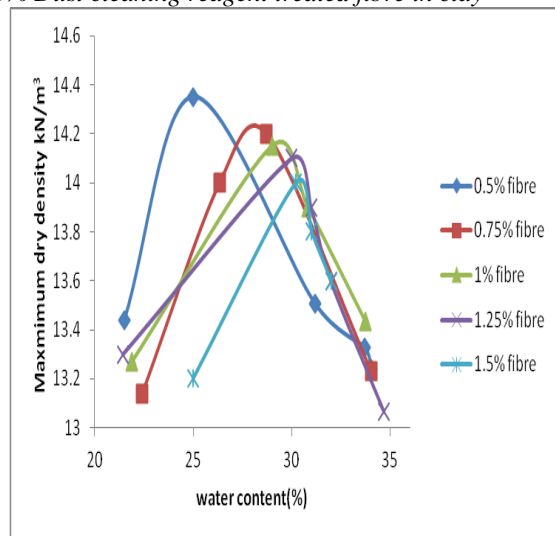


Fig.8. Compaction curves of clay by inclusion of 1% Dust cleaning reagent treated fibre

TABLE 9. COMPACTION RESULT FOR CLAY BY INCLUSION OF 1% DUST CLEANING REAGENT TREATED FIBRE

Percentage of fibre(%)	Values	
	Maximum Dry Density(kN/m ³)	Optimum Moisture Content (%)
0.5	14.35	25.2
0.75	14.2	28.73
1.0	14.15	29
1.25	14.1	30
1.5	13.9	32

4) 2% Dust cleaning reagent treated fibre in clay

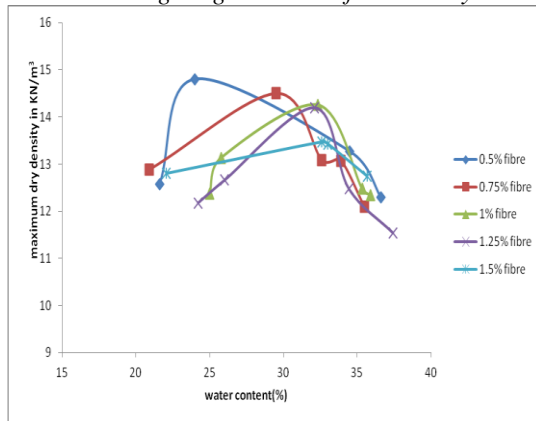


Fig.9. Compaction curves of clay by inclusion of 2% Dust cleaning reagent treated fibre

TABLE 10. COMPACTION RESULT FOR CLAY BY INCLUSION OF 2% DUST CLEANING REAGENT TREATED FIBRE

Percentage of fibre(%)	Values	
	Maximum Dry Density (kN/m^3)	Optimum Moisture Content (%)
0.5	14.8	24.10
0.75	14.5	28.10
1.0	14.24	29.00
1.25	14.2	30.15
1.5	14	31.11

G. Comparison between treated and untreated coir fibre in clay

1) Variation in Maximum dry density

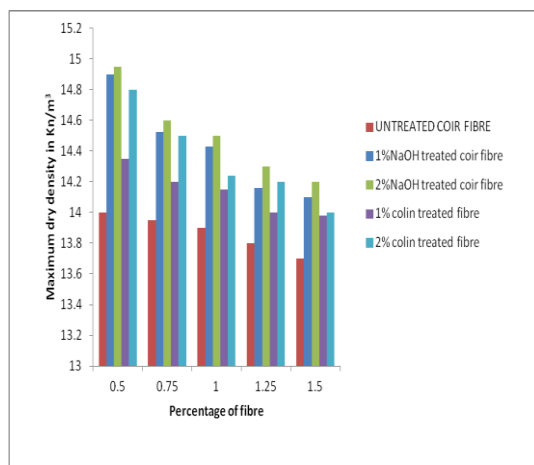


Fig.10. Variation in maximum dry density

The maximum dry density was higher for treated fibre than untreated fibre because due to treatment there will be surface irregularities in the surface of coir fibre and hence denser packing of clay happens.

2) Variation in optimum moisture content

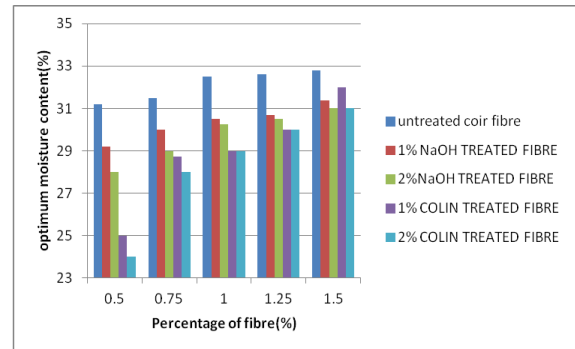


Fig.11. Variation in optimum moisture content

The optimum moisture content was higher for untreated fibre than treated fibre due to the presence of hemicellulose in coir fibre and washed away by treatment.

3) Variation in shear strength

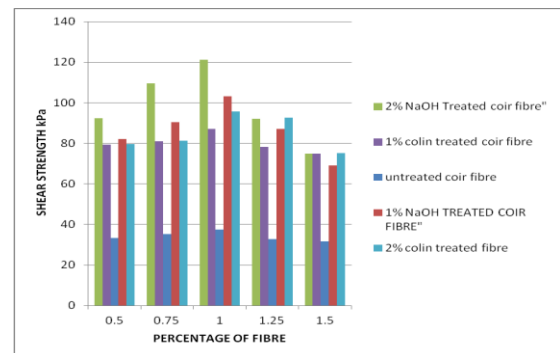


Fig.12. Variation in shear strength

TABLE 11. SHEAR STRENGTH OF CLAY BY INCLUSION OF TREATED AND UNTREATED FIBRE

Percentage of fibre (%)	Shear strength (kPa)				
	Untreated	1% NaOH	2% NaOH	1% Dust cleaning reagent	2% Dust cleaning reagent
0.5	33.44	82.23	92.45	79.44	79.5
0.75	35.27	90.55	109.5	81.06	81.4
1.0	37.39	103.3	121.27	87.72	95.7
1.25	32.66	87.13	92.09	78.27	92.69
1.5	31.72	69.4	75.04	75.02	75

The shear strength was calculated by unconfined compression test. Among these 2%NaOH treated fibre in clay shows higher value due to high bleaching action of sodium hydroxide. The treatment using reagents removes impurities such as lignin, pectin, hemicellulose from coir fibre and pores are free from impurities. To these pores clay will get bonded and improves bonding hence improves shear strength.

4) Variation in CBR

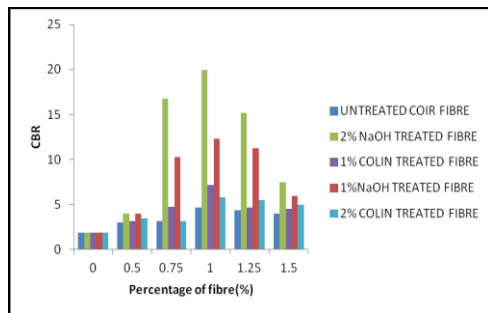


Fig.13. Variation in CBR

TABLE 12. CBR OF CLAY BY INCLUSION OF TREATED AND UNTREATED FIBRE

Percentage of fibre (%)	CBR				
	Un treated	1% NaOH	2% NaOH	1% Dust cleaning reagent	2% Dust cleaning reagent
0.5	3	4	3.99	3.2	3.5
0.75	3.19	10.25	16.78	4.79	3.21
1.0	4.7	12.35	19.98	7.19	5.8
1.25	4.4	11.25	15.18	4.7	5.5
1.5	4	6	7.5	4.5	5

The CBR for 2%NaOH treated fibre in clay shows higher value due to high bleaching action of sodium hydroxide. The treatment using reagents removes impurities such as lignin, pectin, hemicellulose from coir fibre and pores are free from impurities. To these pores clay will get bonded and improves bonding. The optimum percentage was obtained as 1%.

5) Scanning Electron Microscopy

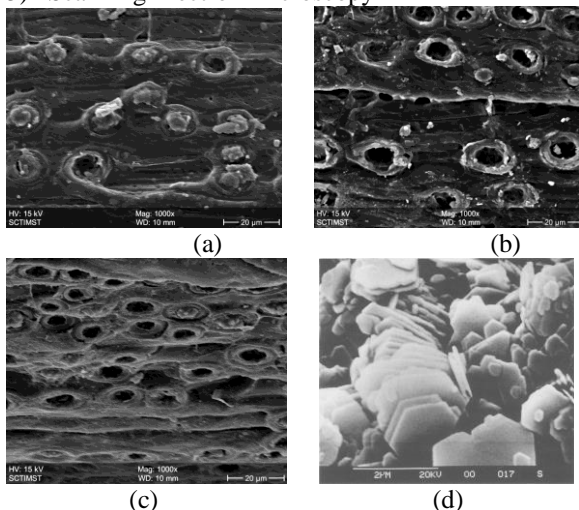


Fig.14. SEM images of (a)untreated coir fibre (b) NaOH treated fibre (c) colin treated fibre (d) kaolinite clay

The SEM images show that untreated fibers have impurities in the pores of coir fibre. The Sodium hydroxide and colin treated fibres removes impurities present in coir fibres such as lignin, pectin and hemicelluloses and the clear pores are visible in the image. The pore size of coir fibre is recorded as nearly 20micrometre and the size of clay was

recorded as nearly 2 micronmetre, hence the clay fits into the pores of coir fibre and hence the bonding strengthens.

IV. CONCLUSION

From the study the CBR and shear strength of clay was improved by the addition of coir fibre. For each tests the optimum percentage was obtained as 1% .

a) By addition of coir fibre the maximum dry density decreases due to the replacement of low specific gravity coir fibre by high specific gravity clay

b) By addition of coir fibre the optimum moisture content increases due to the large amount of pores in coir fibre and hemicellulose of coir fibre which are responsible for absorption of water.

c) The shear strength of clay was improved by the addition of coir fibre. This is due to interlocking of coir fibre with clay.

d) The shear strength of clay was improved by almost thrice by the addition of treated fibre than that of untreated fibre . This is due to removal of impurities like lignin, pectin and hemicellulose of coir fibre which causes surface irregularities hence responsible for good bonding.

e) The optimum percentage of fibre obtained as 1% . Beyond 1% the shear strength decreases due to fibre percentage becomes more

f) Among the reagents used 2% NaOH treated fibre in clay shows a higher improvement. This is due to high bleaching action of sodium hydroxide.

g) The CBR was improved by the addition of coir fibre.

h) Greater improvement was noted for treated fibre compared to untreated fibre. This is due to the formation of surface irregularities in coir fibre due to treatment.

i) From the SEM study the pores of coir fibre was noted as nearly 20micrometre and the size of the clay as 2 micrometre hence clay will fit into the pores of coir fibre and enhances bonding.

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