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

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***Abstract*— Reinforced soil imparts greater strength to the soil. The reinforcement used is 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 reagent like sodium hydroxide and dust cleaning reagent. A series of compaction tests were conducted and the optimum moisture content was obtained and from the result unconfined compression test, CBR were conducted and an improvement in the strength parameters was studied.**

***Keywords*— coir, sodium hydroxide, dust cleaning reagent, clay**

I. INTRODUCTION

Soil has been used as a construction material from pastl. Weak soils are poor in mechanical properties, it has been putting challenges to civil engineers, to improve its properties depending upon the requirement which varies from site to site. Addition of fiber in soil improves the overall engineering performance of soil. Fiber reinforced soil has been used in many countries in the recent past . Fiber 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,Dust cleaning reagent.Sodium hydroxide was purchased from Chemical laboratory shop Trivandrum. Dust cleaning reagent was purchased from Local market Banglore.

B. Methodology

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

III. RESULTS AND DISCUSSIONS

The table 1 shown below gives the properties of the kaolinite clay collected from the English Indian Clay

TABLE I. PROPERTIES OF THE 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

TABLE II. PROPERTIES OF COIR

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

TABLE III. 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 IV. `: PROPERTIES OF DUST CLEANING REAGENT

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

A. Compaction tests in clay by untreated coir fibre

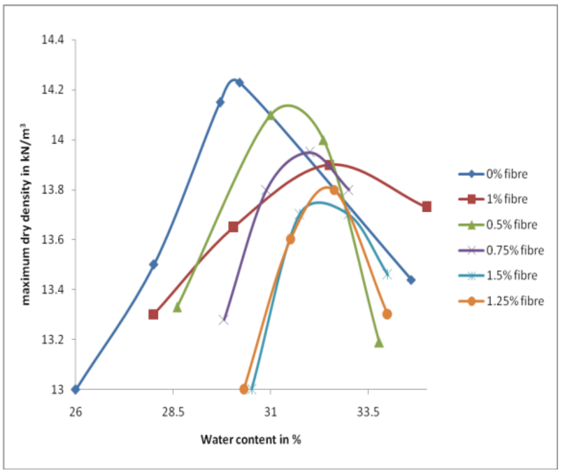


*Fig 1.*Compaction curves by inclusion of untreated fibres

TABLE V. COMPACTION RESULT FOR CLAY BY INCLUSION OF UNTREATED COIR FIBRE

Percentage of fibre (%)	Values	
	Maximum Dry Density(kN/m³)	*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

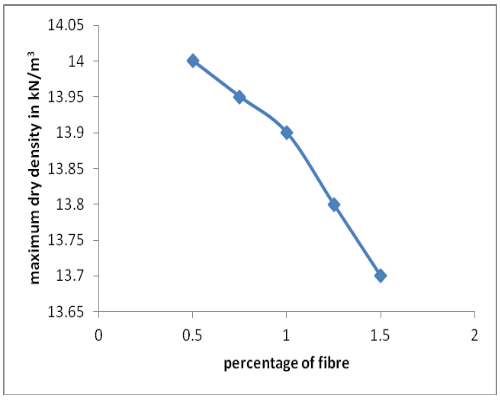


*Fig 2.*Variation in maximum dry density

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

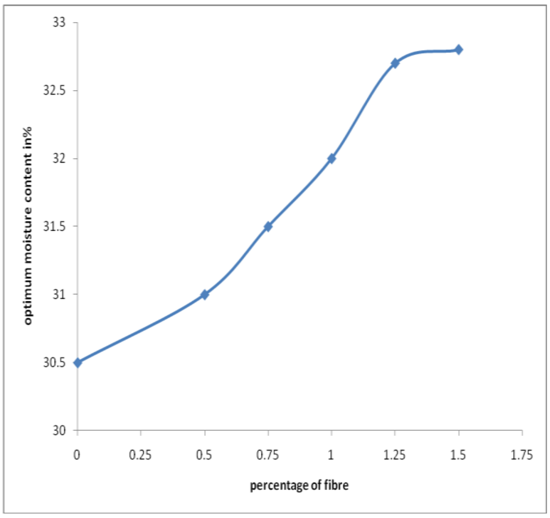


*Fig 3.*Variation in optimum moisture content.

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

D. Variation in shear strength

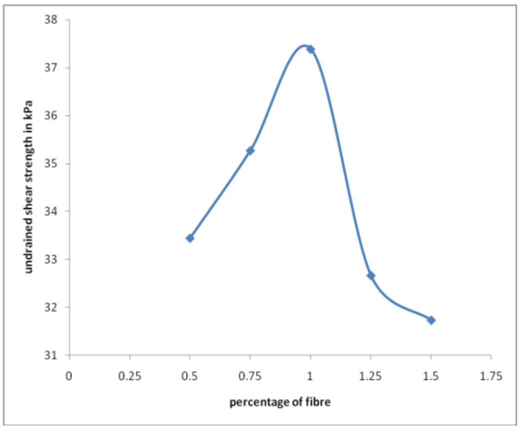


*Fig 4.*Variation in shear strength.

The shear strength was imoproved 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

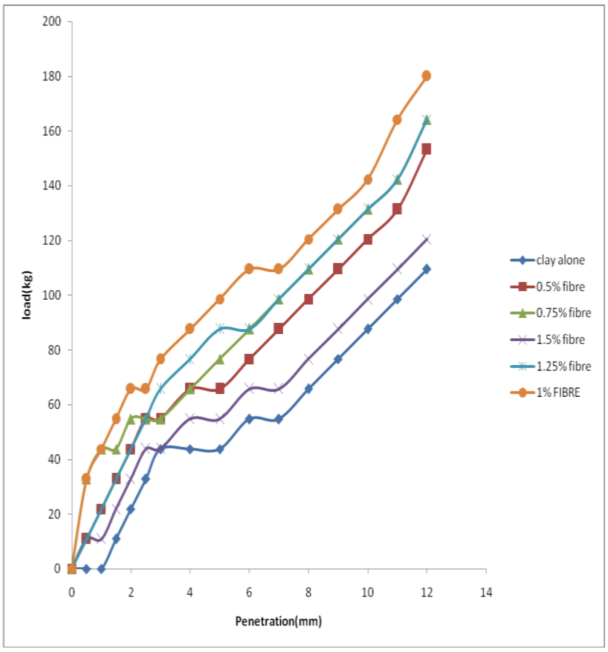


Fig 4. Load penetration graph.

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 was 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%NaOH treated fibre.

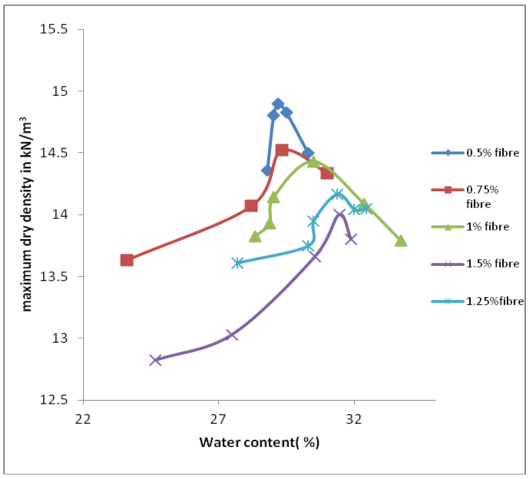


Fig 5. Compaction curves of clay by inclusion of 1%NaOH treated fibre

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

Percentage of fibre	Values	
	Maximum Dry Density	***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% NaOH treated fibre in clay

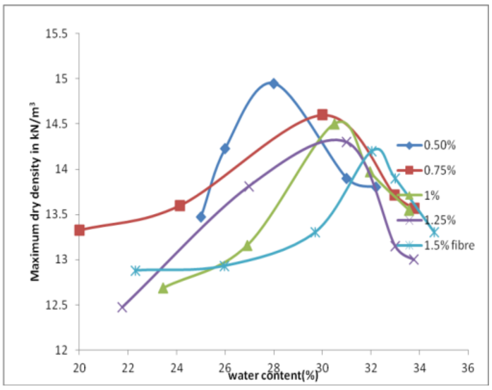


Fig 6. Compaction curves of clay by inclusion of 2%NaOH treated clay.

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

Percentage of fibre	Values	
	Maximum Dry Density(kN/m³)	*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

- 1% Dust cleaning reagent.

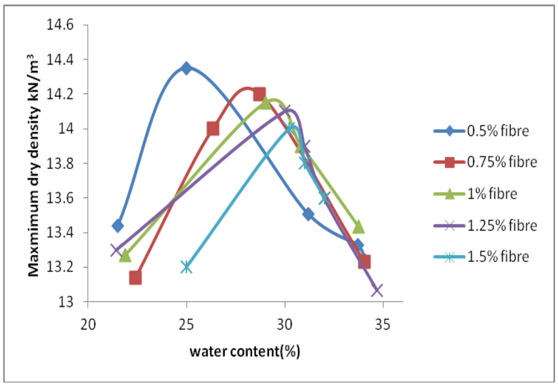


Fig 4. Compaction curves of clay by inclusion of 1%Dust cleaning reagent treated fibre.

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

Percentage of fibre(%)	Values	
	Maximum Dry Density(kN/m³)	*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

- 2% Dust cleaning reagent treated fibre in clay

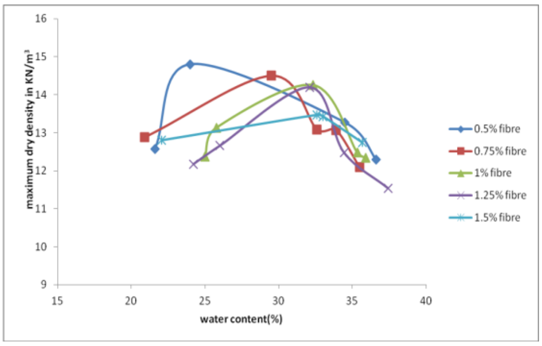


Fig 7. Compaction curves of clay by inclusion of 2%Dust cleaning reagent treated fibre.

Percentage of fibre(%)	Values	
	Maximum Dry Density (kN/m³)	*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

- Variation in Maximum dry density

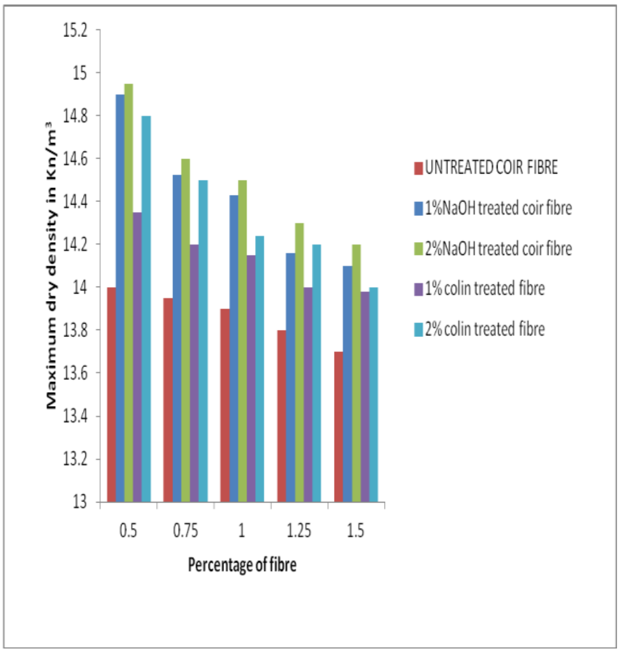


Fig 8. Variation in maximum dry density.

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.

- Variation in optimum moisture content

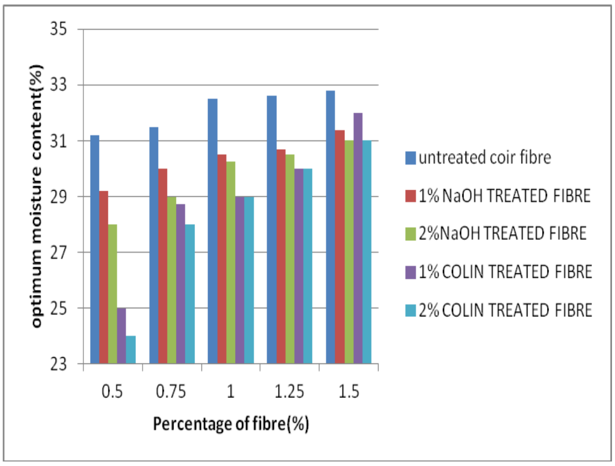


Fig 9. Variation in optimum moisture content.

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

- Variation in shear strength

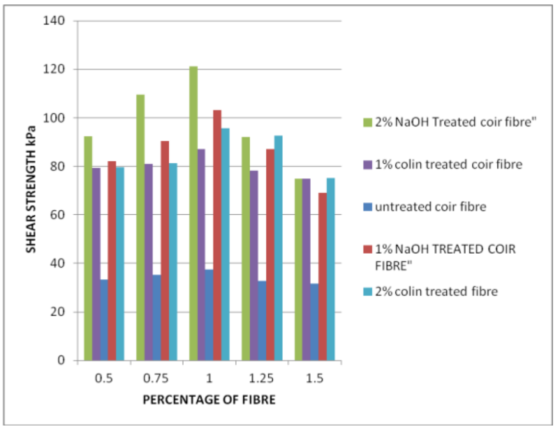


Fig 10. Variation in shear strength.

TABLE IX. 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.

- Variation in CBR

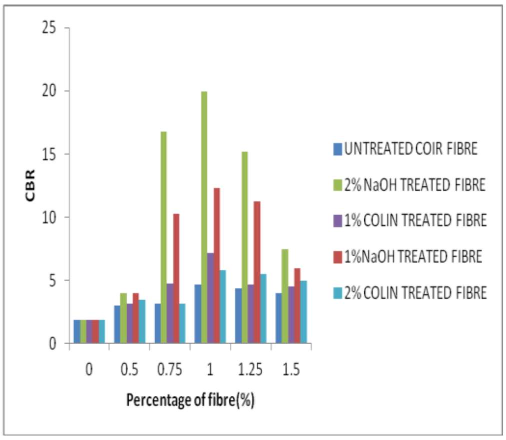
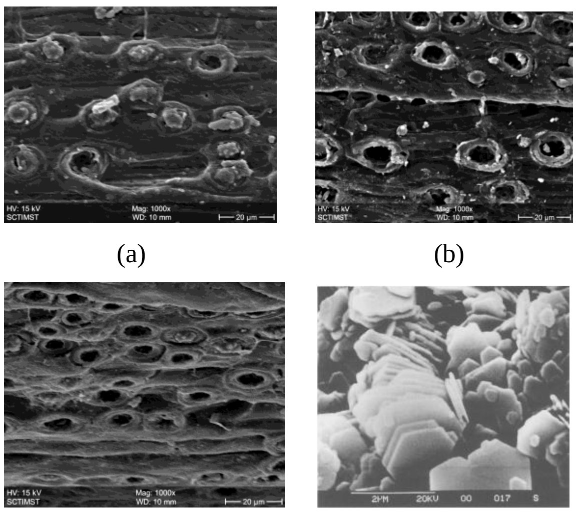


TABLE X. CBR OF CLAY BY INCLUSION OF TREATED AND UNTREATED FIBRE

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%.

- Scanning Electron Microscopy



(a) (b)

(c) (d)

Fig 11. SEM images of(a).untreated coir fibre (b) NaOH treated fibre (c) colin treated fibre (d) kaolinite clay

The SEM images shows 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 are 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. CONCLUSIONS

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 absobtion 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.

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