ASSESSMENT OF STRENGTH BEHAVIOUR OF COHESIONLESS SOIL EMBEDDED WITH WASTE FIBRE MATERIALS

Nikhil Kumar[1], Arvind Kumar [2]
[1] M.Tech , Department of Civil Engineering, Greater Noida Institute of Technology ,Greater Noida , India,
[2] Asst. Professor Arvind Kumar, Department of Civil Engineering,
Greater Noida Institute of Technology, Greater Noida , India.

Abstract : The usefulness of randamonly dispersed waste fibres is shown in this article via a series of experiments conducted on cohesion-free soil with coir fiber. Soil reinforcement is a method of treating soil in order to enhance its performance. The Strengthening By using waste fibers such as coir fiber, which is environmentally benign, soil may be improved. Using the above-mentioned materials, rather than synthetic fibers, is the most appropriate, cost-effective, and environmentally responsible option. Instead of manufactured fibers, researchers can readily purchase natural or waste fibers. Natural fibres' biochemical characteristics aid in producing the optimum soil reinforcement and increasing soil shear strength. The swelling capacity, plastic limit, liquid limit, plasticity index, shear strength, cohesion, and compaction properties of the cohesion-less soil are all evaluated. Reinforcement techniques are used on soils with low stability. Various coir fibre percentages (0, 0.5, 1.0, 1.5). The tests were carried out with the sample on four proportions of 0, 0.5, 1.0, and 1.5. However, each of these combinations is carried out at a distinct soil density and moisture content ratio. Direct shear test, conventional proctor test, and unconfined compressive test were used in this investigation. As a result, data such as stress/ displacement and stress/ strain graph may be compared. We can calculate the C-value of reinforced soil using the results of this experiment. Slope protection, building foundations, and pavement layers are all built using this material.

***IndexTerms* - soil reinforcement, small-scale direct shear test, compaction, coir fibre, shear strength, unconfined compression strength test ,cohesion less soil(sandy soil with slight plasticity).**

I. INTRODUCTION

Natural materials and waste fibers are environmentally friendly, while synthetic fibers are also utilized as a fibre reinforced soil (FRS), although they are not environmentally friendly. It has a low capacity to absorb carbon dioxide from the air and a high rate of nitrogen and phosphorus from the soil. Natural fibers are abrasion-free. Natural fibers were used instead of synthetic fibers by several researchers. The unconfined compression strength of the mixes is improved by mixing the fibres, and the post peak strength loss of the mixtures is reduced. Natural fibers are less expensive and more readily accessible than petroleum-based synthetic fibers. Before conducting an experiment, soil testing should be performed to determine the classification of the soil and its material characteristics (i.e. liquidity index, plasticity index, liquid limit, plastic limit, OMC, maximum dry density, coefficient of uniformity ,coefficient of gradation , moisture content, specific gravity). I utilized coir fiber to strengthen the cohessionless soil in this experiment. Noncohesive soils are sometimes referred to as cohesionless soils. Clean sandy or gravely soils (well graded or badly graded sand or gravel) have less than 5% fines; sandy or gravely soils with fines include more than 12 percent fines (silty or clayey sand or gravel).

In 1969, French Engineer Henry Vidal developed the idea of soil reinforcement for the first time. Different materials are added to enhance soil engineering characteristics such as shear strength, compressibility, and density.Natural fibers may be classified into three groups depending on their origin: Plant fibers (coir, bamboo, jute, sisal), animal fibers (silk, hair, wool), and minerals are the three types of fibers. Plant fibers for soil reinforcement are more appealing to geotechnical engineers since they are readily accessible and suitable for large-scale use. Plant fibers may be further classified into three categories: Crop species, non-crop species, and invasive species are the three types of species. Rice, coir, flax, and other crop species are examples. Non-crop species include jute, sisal, and hemp. Invasive species are non-native organisms that have a propensity to spread insidiously. "The biochemical characteristics of several significant natural fibres that are often utilized in civil engineering applications are shown in Table 1." Plant fibres include lignin, cellulose, hemicellulose, and micro fibrils in their microstructure. Lignin aids in the defense of internal fibers against germs. Cellulose is essential because it provides flexural and tensile strength.

.

OBJECTIVES

- The main purpose of conducting this research project to enhance the shear strength of soil by reinforcing the soil . we are reinforcing the soil by adding natural fibre and materials. We have to enhance the **C-φ** value between the two interface of soil to know the shear strength of soil and prevent from shear failure.
- If **C-φ** value between the layers of soil is more ,then it would be best for pavement layers project construction ,slope protection and embankment.
- To provide an alternative solution for disposal of natural waste fibres and an economical solution for reinforcement of soil by using these waste fibres.
- The objective of this paper is to study the reinforcement of cohesion less soil by using coir fibre.
- Order to develop various strength characteristics of cohesion less soil using a different percentage of fibres
- Studying interaction behaviour of clayey sand with fibres.
- Order to find physical properties and Engineering properties of clayey sand.

II. LITERATURE REVIEW

Improvement of the engineering behaviour of Sand-Clay mixtures using kenaf fibre reinforcement

Natural fibers have gained appeal among academics and businesses as a means of reinforcing structural components and building materials owing to environmental concerns and cost issues with synthetic fibers. As pressures in the soil mobilize tensile resistance in the fibers, the addition of natural fibers as soil reinforcing components improves shear strength characteristics. Despite its limitations, the direct shear test is one of the most often used methods for providing design engineers with a fast assessment of soil strength characteristics when a specified fine content is present in the soil mixture. As a consequence, the purpose of this research is to report the findings of a series of large-scale direct shear experiments on the compaction and shear strength properties of kenaf fiber reinforced soil. To evaluate the compaction and shear strength properties of unreinforced and reinforced sand-clay mixes, 128 experiments were conducted. The impact of kenaf fiber reinforcing on the stress-displacement relationship, volume change, ductility, and failure state of reinforced soil was then assessed. According to the findings, adding a specific quantity of kenaf fiber to the sand-clay mixture increases the ductility of the mixture, improves the shear strength parameters, and makes it a suitable candidate for use in pavement layers, slope protection, embankment, and building foundations.

This work was published in June 2019 by Nima Esmaeilpourshirvani. The use of kenaf fiber in sand-clay mixes increased soil strength in this research. The tests that were carried out were the direct shear test, the compaction test, and the UCS test..

III. METHODOLOGY

Step by Step Methdology is shown below :

.

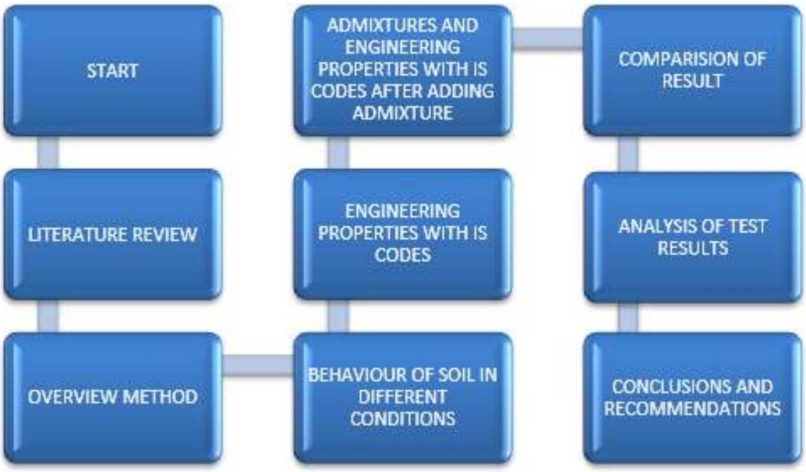

Fig.1. Step by Step Methdology

IV. EXPERIMENTAL PROCEDURE

Test Performed

- **Sieve Analysis:**

After the collection of the soil sample from the selected area first we performed the sieve analysis with practice code of (IS code (IS: 2720 (Part-IV), 1965). First, we have taken the soil sample of 1000 gm and sieved in the laboratory with standard set of sieves with the sizes 4.75mm, 2.36 mm, 1.18 mm, 0.6 mm, 0.25 mm, 0.15 mm, 0.075 mm, pan. Place the required soil sample on the top sieve, close the lid and transfer stack of sieve set to a mechanical sieve shaker. Shake the soil sample for a period of 10 minutes. Remove the stack of sieves on the shaker and record the mass of the material retained on each sieve. Compute the percentage retained on each sieve by dividing the weight retained on each sieve to the original mass of the sample. Compute the per cent finer by 100% and subtract the per cent retained on each sieve as cumulative procedure. In my experiment there is two type of soil. If soil is having much moisture then firstly dried it for 24 hrs. in dry oven for doing sieve analysis. The value of Cu(uniformity coefficient) is mentioned in table 14.

Fig.2. soil sample is dried at a temperature of 105 degree celcius for 24 hrs. in dry oven

Figure 1

Fig.3. During Sieving the Soil samples in Lab.

Fig.4. Data Recorded after sieve analysis method

- **Determination OF Atterberg Limit(liquid limit, plastic limit,shrinkage limit)**

Determination of the consistency limits (Liquid limit, plastic limit, shrinkage limit) as per IS code (2720-(PART-5)-1985). Take 200g of soil sample which is passing through the 425-micron sieve and add water to the desired amount of distilled water to the soil until the paste becomes homogenous. Apply the grease to the Casagrande's apparatus for smooth running. Using ASTM grooving tool make a particular through the soil pat this divides the soil into two symmetric parts. Rotate the handle the 2revolutions minute and count the no of blows, blown. Take 25g of the soil sample from the above soil paste and determine the water content by oven dry method. Take 20g of air-dried soil passing through 425-micron sieve. Take soil of 10g and roll it into soil threads of 3mm diameter between the palm and glass plate. If the thread is 3mm without any cracks that indicates that the water is added more than its plastic limit. Take the 2 or 3 samples and repeat the process and record the average of the soil samples. Up to here the physical properties of the soil is determined. The results of the liquid limit, plastic limit and shrinkage limit is mentioned in table 14.

Fig.5. mixing the soil in brass cup during liquid limit test

- **Direct Shear Test**

Direct shear test is used to find out the soil shear strength parameters such as cohesion (c) and the angle of internal friction (φ). The shear strength is one of the most important factors because workability of structure depends on the soil shearing resistance. The test was conducted by putting the soil at OMC and MDD inside the shear box which is made up of two independent parts. A constant normal load (ς) is applied to obtain one value of c and φ. Horizontal load (shearing load) was increased at a constant rate and applied till the failure point was reached. This load when divided with the area gives the shear strength 'τ' for that particular normal load. The equation for shear strength is given as: $\tau = c + \sigma*\tan(\varphi)$. After repeating the experiment for different normal loads (ς) we obtained a plot which was a straight line with slope equal to angle of internal friction (φ) and intercept equal to the cohesion (c). Direct shear test is the easiest and the quickest way to determine the shear strength parameters of a soil.

This is the maximum shear rate utilized for sand and as the clay content in the mixture increases from 0 to 15%, the shear rate correspondingly decreases from 0.12 mm/min to 0.02 mm/ min to ensure the drained behavior and insignificant excess pore pressure. The vertical loading was applied by a hydraulic jack, maintaining three different surcharges, i.e. 100, 200, and 300 kPa. The horizontal displacement of the lower box is mobilized by an electric servomotor and the horizontal shear force was measured by means of a load cell. The data collected during the test have been sent to the data processing unit for subsequent interpretation purposes. The tests were continued until a strain level of 15% was reached.

Fig. 6. Small-scale Direct Shear Test Equipment

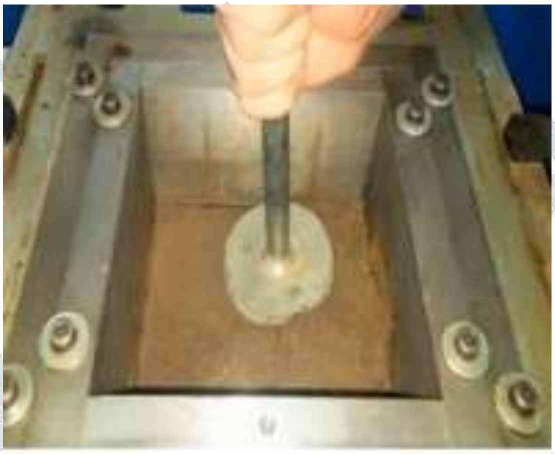

Figure 2

Fig. 7 Soil compaction in shear box

Fig.8 scratching the surface of each layer for proper bonding

Fig.9. Specimen preparation before applying load

Fig.9 coir Reinforcement with soil.

❖ Coir is reinforced with soil for using this in test. Before reinforcing we have to mix soil with coir of length 6-8 inches .coir must be dried, then it is compacted in mould for further test.

- **Experimental testing program for Direct shear test**

Table 1

TEST NO.	COIR FIBRE CONTENT (%)	NORMAL STRESS (kpa)
1	0.0	**200**
2	**0.5**	
3	**1.0**	
4	**1.5**	

Fig.10.. during shear strength test at small-scale direct shear test equipment

V. RESULTS AND DISCUSSION

4.1 Summary of results obtained from proctor test

Table 2

Soil Sample	Mass of soil	Fibre content(%) of soil mass	Optimum moisture Content(OMC) %	Maximum dry density(gm/cc)
Sample 1	Without Fibre	–	12.0	1.64
	With Fibre	0.5	13.0	1.74
		1.0	13.2	1.78
		1.5	15.0	1.80
Sample 2	Without Fibre	–	9.8	1.65
	With Fibre	0.5	10.1	1.69
		1.0	10.2	1.70
		1.5	11.1	1.75

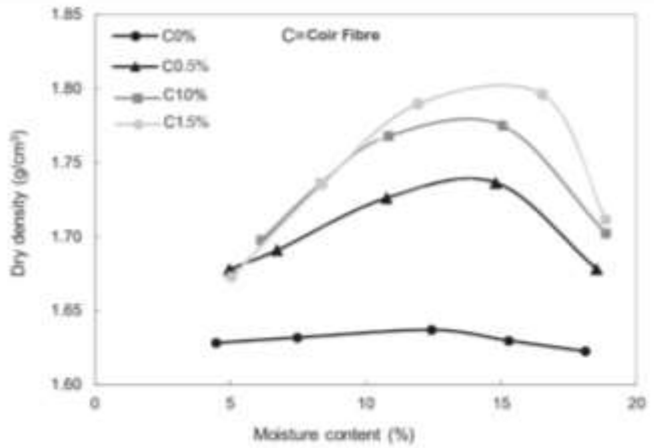

Fig. 11. Sample Soil 1 (SC)

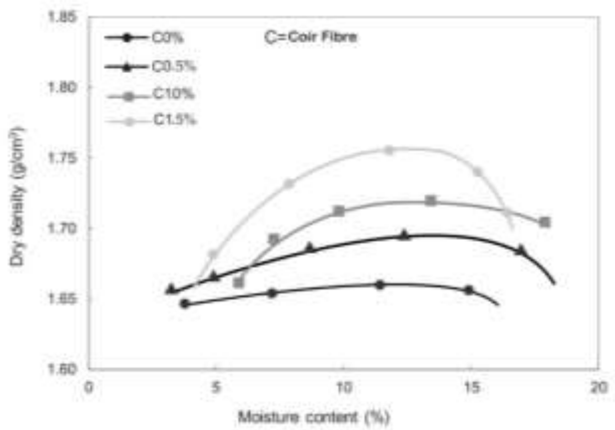

Fig.12. Sample Soil 2(SP)

Table 3 : UCS (unconfined Compressive Strength) Test Results

Soil Sample	Fibre Content(%) of soil mass	UCS (Mpa)
Sample 1 Zeta1 ,Greater Noida	0.0	0.625
	0.5	0.125
	1.0	0.181
	1.5	0.320
Sample 2 Sadipur, Bihar	0.0	0.421
	0.5	0.102
	1.0	0.110
	1.5	0.234

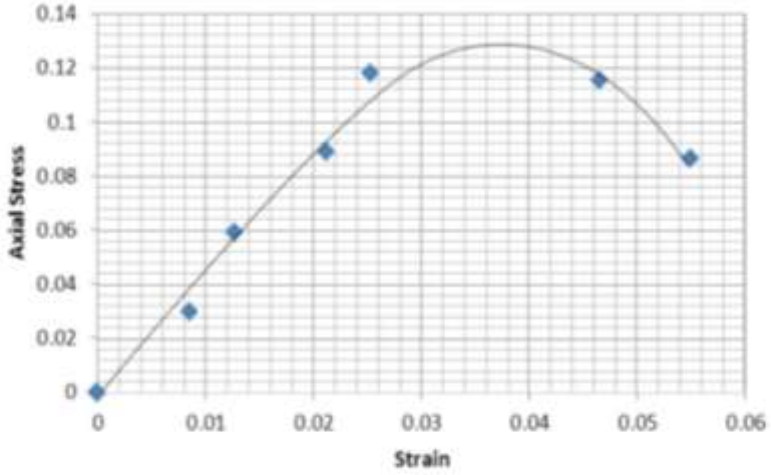

Fig.12. Sample 1 (0.5% fibre), UCS= 0.125

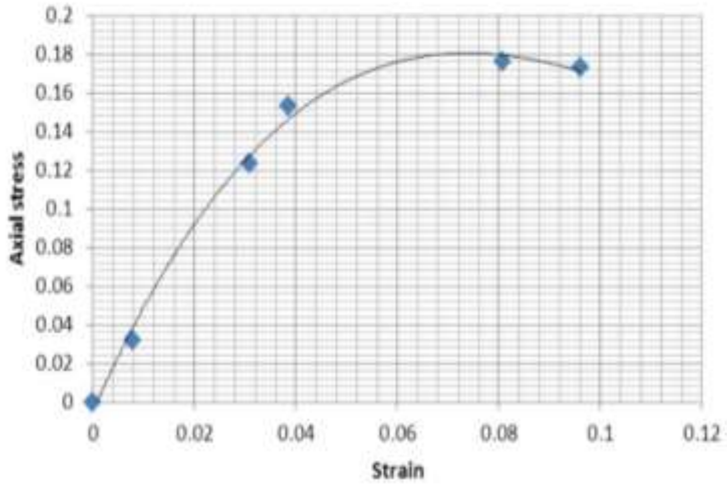

Fig.13 Sample 1 (1.0% fibre), UCS= 0.180

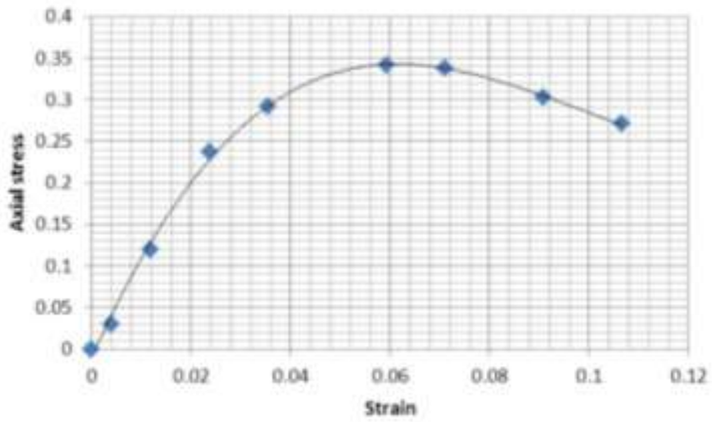

Fig.14 Sample 1 (1.5% fibre), UCS= 0.320

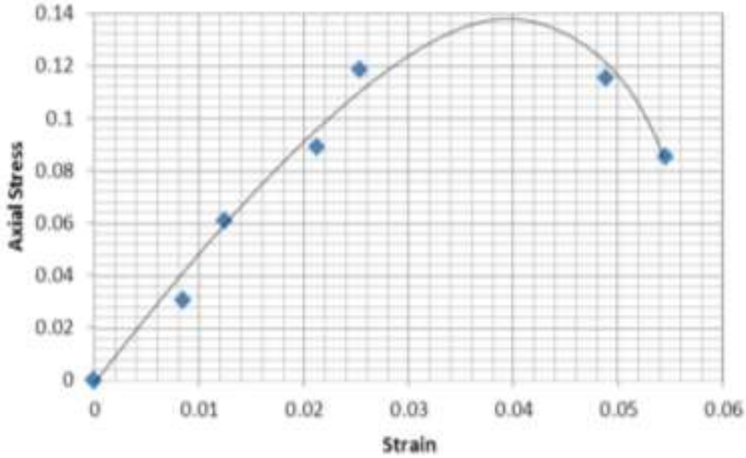

Fig.15 Sample 2 (0.5% fibre), UCS= 0.140

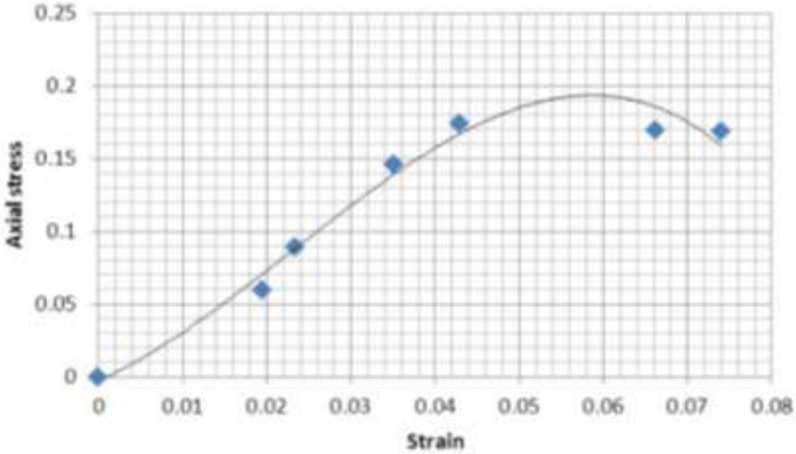

Fig.16 Sample 2 (1.0% fibre), UCS= 0.193

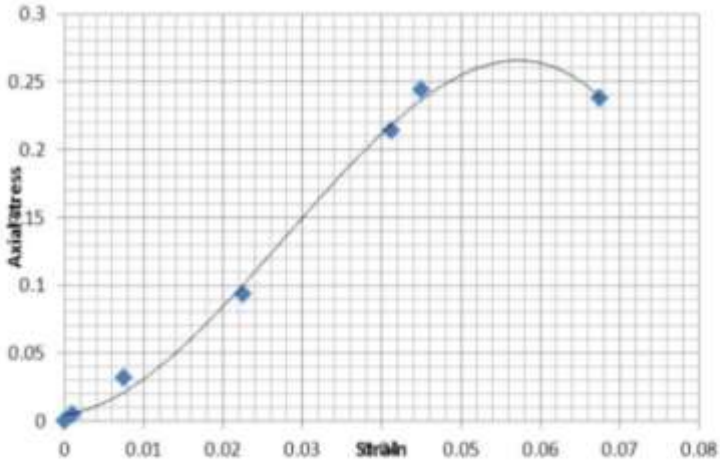

Fig.17 Sample 2 (1.5% fibre), UCS= 0.256

4.3. Direct Shear Test Results

Table 4

Soil Sample	Mass of Soil	Fibre Content(%)	Cohesion(kpa)	Angle of internal friction(degree)
Sample1	Without fibre	–	29.8	47.61
	With fibre	0.5	30.7	49.25
		1.0	33.9	49.67
		1.5	38.5	49.91
Sample2	Without fibre	–	25.2	38.21
	With fibre	0.5	27.5	39.62
		1.0	29.6	40.10
		1.5	32.1	40.42

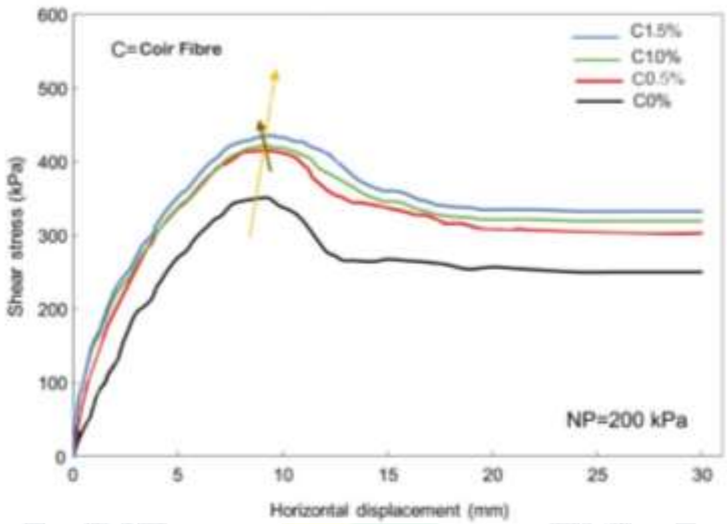

Fig .18 Soil Sample 1

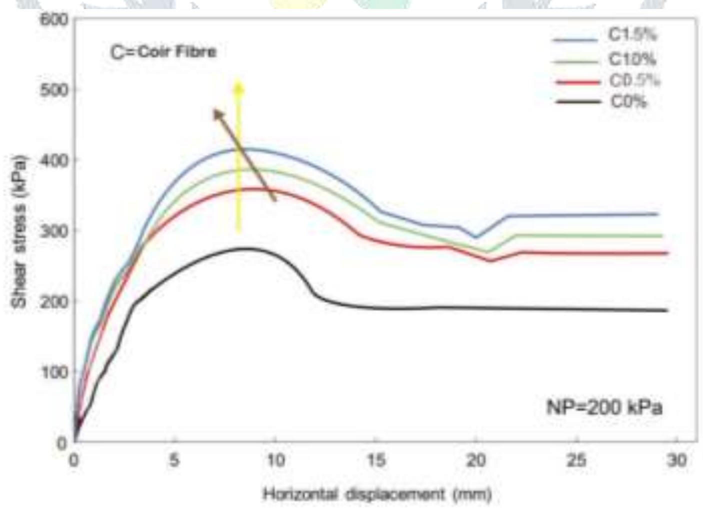

Fig.19 Soil Sample 2

VI. SUMMARY AND CONCLUSIONS

1. The result obtained from direct shear test shows that the soil sample1 with coir fibre reinforcement of 0.5%, 1.0%, and 1.5%. the increase in cohesion was formed to be 30%, 4.1%, and 7.07% respectively and increase in the internal friction (φp) was found to be 0.7%, 0.31% and 0.46% respectively. "Since the net increase in the value of C- φp were observed to be 52% from 30.72 to 38.50 kpa and 15.01% with angle of friction 48.25 degree to 49.81 degree." Therefore the use of coir fibre as reinforcement for soils like soil sample 1 is recommended.
2. On comparing the results from UCS Test of soil sample 1, "it is found that the value of unconfined compressive strength show a net increament of 49.8% from 0.125 Mpa to 0.320 Mpa." This also supports the previous conclusion that use of coir fibres for reinforcing soils like soil sample 1 is recommended.

3. The result obtained from direct shear test shows that the soil sample 2 , with fibre reinforcement of 0.5%, 1.0% and 1.5%. the increase in cohesion was found to be 10%, 4.7% and 3.53% respectively and increase in the internal angle of friction was found to be 0.8%, 0.31% and 0.46% respectively. Since the net increase in the values of C- φ were observed to be 19.6%, from 26.13 kpa to 32.10 kpa and 1.58%, with angle of friction from 38.21 to 40.42 degree respectively. It can be concluded that for such a soil randomly distributed coir fibre reinforcement is not recommended.

4. The results of the UCS Test for soil sample2 were also similar for reinforcement with fibre content of 0.5%, 1.0% and 1.5% the increase in unconfined compressive strength from the initial value as 10.68%, 1.25% and 0.61% respectively. This increment is not substantial and applying it on soils similar to soil sample2 is not effective.

5. Overall it can be concluded that reinforcing soil with fibres can be considered as good ground improvement technique specially in engineering project on weak soils "where it can act as a substitute to deep/raft foundation, highway embankment and slope protection etc. reducing cost of project."

6. As mentioned above conclusion, it concluded that soil 1 (clayey sand) is more suitable for coir reinforcement soil than soil 2 (poorly graded sand). It also concluded that as we increase the amount of coir fibre in soil reinforcement their shear strength parameters value increases.

VII. SCOPE 0F FUTURE WORK

- With this project research , a small attempt has been made at deducing a new method of waste fibers disposal in effective manner .The main aim of this project to use of natural waste fibers in recinforcement of soil soil to enhance the shear strength of the soil. I will check the **C-φ** value between two layers of soil in slope protection. To increase the **C-φ** value between the interface of slopes.
- If **C-φ** value between the layers of soil is more, then it would be best for pavement layers project construction ,slope protection and embankment.

REFERENCES

[1]Nima EsmaeilpourShirvania ,a Department of Civil Engineering, Babol Noshirvani University of Technology.

[2] G.V. Praveen a , Pandu Kurre b a S R University, Warangal, India b Sri Indu Institute of Engineering and Technology, Hyderabad, India.

[3] V.P. Jishnu, N. Sankar , S. Chandrakaran National Institute of Technology, Calicut, Department of Civil Engineering, Kerala, India.

[4] IS:2720 (Part-HQ, 1964) code guidelines to IS Sieve analysis.

[5] IS:2720 (Part-IV, 1965) code guidelines to physical properties of soil.

[6] Huiming Tana, Fumao Chena, Jia Chena, Yufeng Gao College of Harbour Coastal and Offshore Engineering, Hohai University, Nanjing, China b College of Civil and Transportation Engineering, Hohai University, Nanjing, China.

[7] S.M. Dasaka & K. S. Sumesh a Department of Civil Engineering , Indian Institute of Technology Bombay , Mumbai, India.

[8] T. Maliakal Department of Civil Engineering, National Institute of Technology, Calicut 673601, Kerala, India.

[9] R.Sridhar Research Scholor in VTU,Belgaum. Associate Professor, Department of Civil Engg.,Nagarjuna college of Engg. & Technology, Bangalore, India.

[10] IS:2720 (Part-2-1973) code guidelines to unconfined compressive strength test.