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Shear Strength Enhancement of Soil by Using Coconut Fiber

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Abstract : *This project works is being done to enhance the shear strength of soil because soil is the material of earth crust on which each and every civil engineering structures like buildings, dams, roads, railways, tunnel etc. are being placed. We are enhancing the shear strength of soil by using coconut fibres, which will reinforce the soil & enhance its shear. In this project work we are using coconut fibres in different proportion like 0.25%, 0.50% & 0.75% etc. &in different length of coconut fibres like 2cm&4cm.Although the soil of our university is c-φ in nature so we adopted the Tri-axial test in unconsolidated-un-drained condition. We performed the different set of tri-axial test over this soil & get different results. In this test we calculate the optimum moisture content (OMC) & natural water content before performing the Tri-axial test.*

INTRODUCTION

Soil has been used as a construction material for buildings, roads, irrigation structure etc. all over the world. Because of weakness in mechanical properties and strength, soil needs to be improved according to the requirement which varies from site to site. The stabilization is done since many past centuries to enhance the engineering properties of soil. The main method of Stabilization includes mixing the soil with soil of higher strength or binding materials like limestone / cement /calcium or reinforcing with suitable element/fibre. Soil reinforcement increases shear strength of soil & bearing capacity. Soil can be reinforcement by inclusion of high strength metal strips / wire and relatively low modulus natural and/or synthetic fibers. During last few decades, a lot of work has been done to enhance the engineering properties of soil and it has been found that addition of fibre is an efficient way to enhance the engineering performance of soil. Sand silt and clay may be reinforced with coconut fibres. The concept of reinforcement of soil with natural fibres is an ancient practice. Natural fibres are locally available and can make composites with cement/lime, cheaper, biodegradable and environmental friendly. There are many fibres e.g. Coconut (coir), Jute, Sisal, palm, rice husk, barley straw etc. are in use for soil reinforcement.

Shear Strength

The shear strength of soil is a result of frictional resistance and interlocking pattern of soil particles, and possibly bonding at particle contacts. Shearing resistance of a soil is the property of soil that enables the soil to keep its equilibrium when its surface is not level or for that matter, under any load condition which produces shearing resistance. It may be presented by-
Shear strength of soil (τ)

$$\tau = c + \sigma \tan \phi$$

Where, τ=shear stress
c=cohesion, ϕ=angle of internal friction

LITERATURE REVIEW

Hejazi et al. (2012) Soil reinforcement is done with the help of various natural fibres Coconut (coir) fiber, Sisal, Palm fibers, Jute, Flax, Bamboo, Cane and artificial fibres like Polypropylene (PP), fibers Polyester (PET),fiber Polyethylene (PE), Glass fibers, Nylon fiber, Steel fibers Polyvinyl alcohol (PVA)Soil is mixed with these fibres in two ways either manually or mechanically. After that various properties of soil are tested like cohesion, angle of internal friction, shear strength. It is found that the shear strength of soil increased after introduction of fibres.

Maury etal. (2007) In this paper coir fibers is used for soil stabilization .Coir fibers are mixed in soil by manual mixing .The %age of coir fiber in each soil sample was gradually increase like 0.25%,0.50%0.75%, 1 % and various test are performed like UCS and CBR.

- Soaked CBR value found to increase from 4.75% to 9.22%, unsoaked CBR values found to increase from 8.72% to 13.55%.

- UCS value found to increase from 2.75kg/cm^2 to 6.33kg/cm^2

It was concluded that the usage of coir fibre reinforced soil improved the properties of soil and its strength.

Chaple et al. (2011) This journal describes the coir fibers reinforced clayey soil properties .In this clay soil is mixed with coir fiber in increase proportion of %age and tests are conducted to determine the effect of fiber on bearing capacity and settlement of square footing in clayey soil .It is observed that bearing capacity increases and settlement decreases due to coir reinforced clayey soil.eIt was also observed that maximum bearing capacity of soil was when it is mixed with coir in the proportion of 0.50%

Dharmendra Kumar In the 21th century application of jute fibre in civil construction work has attend pace especially for subgrade of flexible pavement. Savastano et al. (2000) used waste jute fibers as reinforcement for cement-based composites in construction work instead of concrete. Dhariwal (2003) carried out performance study on California bearing ratio (CBR) of fly ash reinforced with jute and non-oven fibers. Sanyal (2005) studied soil improvement by using jute fibre and applied Jute Geotextiles in Rural Roads. Chandra et al. (2008), studied CBR and shear values of Jute fibre for preparation of fibre reinforced flexible pavements. Saran (2010) gives brief discussion about the reinforced soil and its engineering applications. Islam and Iwashita, (2010) used jute reinforced material to construct earthquake resistance building for low income stack holders. Aggarwal and Sharma (2010), used bitumen coated jute with different fibre lengths and varying percentages to reinforce soil and found that jute fiber reduces the MDD with the increases the OMC. They obtained Maximum CBR value (2.5 times than plain soil CBR) with 10 mm long and 0.8% jute fiber. Islam and Ivashita (2010) showed that jute fibers are effective for improving the mortar strength as well as coherence between block and mortar. Singh (2012) studied improvement in CBR value of soil reinforced with jute and coir fiber in comparative manner and suggested dominance of jute fibre. Singh and Bagra (2013) studied the influence of different length and diameter of Jute fiber on the CBR value of Itanagar, A.P., India soil used in the construction of embankments and pavement subgrade and results were compared with that of unreinforced soil. Pandey et al. (2013) studied soil stabilization using pozzolanic material and Jute fibre.

Kundan Meshram et.al –Now-a-days, geotextiles are widely used in highway engineering, to solve a variety of problems related to drainage, separation and reinforcement of pavement structure. Geotextiles made of natural fibres such as coir, jute etc., are emerging as alternatives to polymeric geotextiles. Coir net is readymade material, cheap, easy laying in field and biodegradable. Under the traffic loads, the soil sub-base is subjected to compression in the vertical direction accompanied by tension in the lateral direction. Also, during dry weather conditions, cracks develop at the soil surface due to tensile stresses induced as a result of drying and shrinkage. During wet weather conditions, water starts to rise in the sub-base by capillary action from soil sub-grade. Materials like coir, lime etc. are needed to improve the compressive as well as the tensile strength and the permeability characteristics of the sub-base for a better performance of the pavements.

R.R.Singh et.al It represents a study to analyze both un-soaked and soaked CBR value of soil increases with the increase in fiber content. Soaked CBR value increases from 4.75% to 9.22% and un-soaked CBR value increases from 8.72% to 13.55% of soil mixed with 1% coir fiber. UCS of the soil increases from 2.75 kg/cm² to 6.33 kg/cm² upon addition of 1% randomly distributed coconut fiber. Adding of coconut coir fiber results in less thickness of pavement due to increase in CBR of mix and reduce the cost of construction and hence economy of the construction of highway will be achieved. This is because of composite effect of natural fiber changes the brittle behavior of the soil to ductile behavior.

Amit tiwari et.al – represents a study focus on to analyze property of soil such as Atterberg's Limits, Compaction Curve (O.M.C. and M.D.D.), Shrinkage Limit, California Bearing Ratio, Swelling Pressure, Permeability, direct shear test, effect of Fly Ash, Coconut fiber& crushed Glass with various percentages along with Black cotton Soil, combination on the above proportion of ingredients, use of waste products instead of conventional materials like cement, lime, etc. & how to increase cost benefit ratio. To achieve this goal experimental study on 48 trial samples test were carried in two phase such as in first phase, the physical properties of soil such as hygroscopic moisture content grain size distribution, specific gravity, Atterberg's second phase, various test investigation performed on black cotton soil using different percentages of Fly Ash (FA) at 10%, 15%, 20%, 25%, Coconut Coir Fiber (CCF) at 0.25%, 0.5%, 0.75%, 1% & Crushed Glass (CG) at

3%, 5%, 7% (glass crushed to have gradation of sand size). limits, Direct shear test, Swelling pressure, MDD-OMC, CBR, Permeability test values are determined.

Asaduzzaman et.al(2014)

This paper presented work on improvement of soil properties like bearing capacity, settlement by using bamboo fibre reinforcement. The dimension of fibre is taken as Length-2 AND 4 CM. The fibre was introduced into the soil in multilayer at depth 0.75 inch, 1.5 inch, 2.25 inch. It was obtained that load bearing capacity of single layer reinforced soil increase 1.755 times and 2.02 times for multiple reinforced system under square footing Different size of square footing are used like 3 inch*3 inch ,4.5 inch*4.5 inch.

METHODOLOGY

Sample collection: We collected total amount of soil was approximately of 30 kg. This soil was made free from debris, plastics, kankar and other unwanted materials. The collected sample is clayey silt.

Different tests are performed on the soil sample and which are explained below-

1. Natural water content
2. Optimum moisture content & Maximum Dry Density
3. Triaxial Test (Unconsolidated Undrained)

Water Content in Soil by Oven Drying Method

1. Clean the container, dry it and weigh it with the lid (Weight 'M_1 ').
2. Take the required quantity of the wet soil specimen in the container and close it with the lid .take the mass M_2
3. Place the container, with its lid removed, in the oven till its weight becomes constant (Normally for 24hrs).
4. When the soil has dried, remove the container from the oven, using tongs.
5. Find the weight 'M_3 'of the container with the lid and the dry soil sample.

$$W=M_2-M_3/M_3-M_1\times100$$

Where M_1=Mass of empty container with lid
M_2=mass of the container with wet soil and lid
M_3= mass of container with dry soil and lid.

Determination of OMC and MDD through standard procter test

In this method, the maximum dry density and optimum moisture content of soils is obtained by using the results of standard proctor curve to enter a family of curves from which the maximum dry density and optimum moisture content can be determined.

Procedure for OMC-

1. Take about 20 kg of air dry soil .sieves it through 20 mm and 4.75mm IS sieves .
calculate the %age retain on 20 mm sieves, and 4.75 mm sieves ,and the % age passing 4.75mm sieves. Do not use the soil retain on 20 mm sieves .determine the ratio of friction retained and that passing 4.75mm sieves.
2. IF %age retained on 4.75 mm sieves is greater than 20 mm use the larger mould of 150 mm dia .if it is less than 20 %, the standard mould of 100 mm diameter can be used.
3. Mixed the soil retained on 4.75 mm sieves and that passing 4.75 mm sieves in the proportion determine in step 2to obtain about 16 to 18 kg of soil specimen.
4. Clean and dry the mould and the base plate.
5. Weight the mould with the base plate to the nearest of 1 gm
6. Take about 16 to 18 kg of soil specimen. Add water content about 4 %if the soil is sandy and to about 8% if the soil is clay.
7. Keep the soil in an air –tight container for about 18 to 20 hrs for maturing.
8. Attack the colar to the mould .place the mould on soil based
9. Take about 2.5 kg of the processed soil ,and place it in the mould in 3 equal layer
Take about 1 /3 of the quantity first, and compact it by giving 25 blows of the rammer. The blows should be uniformly distributed over the surface of each layer. The top surface of the first layer should be scratched with the spatula before placing the second layer .the second layer should also be compacted by 25 blows of hammer.
10. Remove the collar and trim of the excess soil projecting above the mould using a straight edge
11. Clean the base plate and the mould from outside. Weight it to the nearest gram.
12. Remove the soil from the mould.
take the soil sample for the water content determination from the top, middle ,bottom portion
13. Add about the 3 % of the water to a fresh portion of the proceed soil and repeat the step 10 to 14.

Dry density = (M/V)/ (1+w)
Where M=total mass of soil
V=volume of soil

W=Water content

We do all the given process through 3 samples and OMC -18%

Triaxial Test (Unconsolidated-Un-drained)

1. Take 3 kg of soil and mix 12% of water.
2. Measure diameter, length, and initial mass of the specimen.
3. Measure the thickness of the rubber membrane.
4. Set a soil specimen in a tri-axial chamber.
5. Increase the cell pressure to a desired value (70 kPa for the first case and 140kN in the second case).
6. Shear the specimen at the rate of 1%/min or 0.7 mm/min (for 70 mm sample height).
7. In automated device, the software calculates it automatically based on the soil type.
8. Record ΔL, and σ_d in every 10 seconds (computer does it automatically).
9. Continue the test until the deviator stress shows ultimate value or 20% axial strain.
10. After completion of the test, release the cell pressure to 0, vent the pressure an
11. Bring the cell down by bring the lower platen down, drain the cell, and clean the porous stone and the assembly.
12. Sketch the mode of failure.
13. Measure the weight of the soil specimen again, and put the specimen into the oven.
14. Measure the weight again after 24 hours.
15. Repeat the test for the second specimen too (140 kPa of cell pressure and third specimen 210 kPa of cell pressure)

C	32kN/m^2
Φ	10˚

Procedure of tri-axial for 2cm with 0.25% coconut fibre (By Weight)-

1. Take 3 kg of soil and mix 12% of water.
2. Measure diameter, length, and initial mass of the specimen.
3. Measure the thickness of the rubber membrane.
4. Set a soil specimen in a tri-axial chamber.
5. Increase the cell pressure to a desired value (70 kPa for the first case and 140 kPa in the second case).
6. Shear the specimen at the rate of 1%/min or 0.7 mm/min (for 70 mm sample height). In automated device, the software calculates it automatically based on the soil
7. Record ΔL, and σ_d in every 10 seconds (computer does it automatically).
8. Continue the test until the deviator stress shows ultimate value or 20% axial strain.
9. After completion of the test, release the cell pressure to 0, vent the pressure and
10. Bring the cell down by bring the lower platen down, drain the cell, and clean porous stone and the assembly.
11. Sketch the mode of failure.
12. Measure the weight of the soil specimen again, and put the specimen into the oven.
13. Measure the weight again after 24 hours.
14. Repeat the test for the second specimen too (140 kPa of cell pressure and third Specimen 210 kPa of cell pressure)

C	32kN/m^2
Φ	11˚

Procedure of tri-axial 2cm fiber (0.50%)

1. Take 3 kg of soil and mix 12% of water.

1 Measure diameter, length, and initial mass of the specimen.

2 Measure the thickness of the rubber membrane.

3 Set a soil specimen in a tri-axial chamber.

4 Increase the cell pressure to a desired value(70 kPa for the 1st case and 140 kPa in the 2nd)

6. Shear the specimen at the rate of 1%/min or 0.7 mm/min (for 70 mm sample height). In automated device, the software calculates it automatically based on the soil type.
7. Record ΔL, and σd in every 10 seconds (computer does it automatically).
8. Continue the test until the deviator stress shows ultimate value or 20% axial strain.
9. After completion of the test, release the cell pressure to 0, vent the pressure & bring the cell down by bring the lower platen down, drain the cell, and clean the porous stone and the assembly.
10. Sketch the mode of failure.
11. Measure the weight of the soil specimen again, and put the specimen into the oven.
12. Measure the weight again after 24 hours.
13. Repeat the test for the second specimen too (140 kPa of cell pressure and third specimen 210 kPa of cell pressure)

C	30.5kN/m^2
Φ	11.8˚

Procedure of tri-axial of 2 cm fiber (0.75%)

1. Take 3 kg of soil and mix 12% of water.
2. Measure diameter, length, and initial mass of the specimen.
3. Measure the thickness of the rubber membrane.
4. Set a soil specimen in a tri-axial chamber.
5. Increase the cell pressure to a desired value (70 kPa for the first case and 140

in the second case).

6. Shear the specimen at the rate of 1%/min or 0.7 mm/min (for 70 mm sample height).
   In automated device, the software calculates it automatically based on the soil type.
7. Record ΔL, and σd in every 10 seconds (computer does it automatically).
8. Continue the test until the deviator stress shows ultimate value or 20% axial strain.
9. After completion of the test, release the cell pressure to 0, vent the pressure and
10. Bring the cell down by bring the lower platen down, drain the cell, and clean the porous stone and the assembly.
11. Sketch the mode of failure.
12. Measure the weight of the soil specimen again, and put the specimen into the oven.
13. Measure the weight again after 24 hours.
14. Repeat the test for the second specimen too (140 kPa of cell pressure and third Specimen 210 kPa of cell pressure).

C	29.5kN/m^2
Φ	12.1˚

Procedure of tri-axial 4cm fiber (0.25%)

1. Take 3 kg of soil and mix 12% of water.
2. Measure diameter, length, and initial mass of the specimen.
3. Measure the thickness of the rubber membrane.
4. Set a soil specimen in a tri-axial chamber.
5. Increase the cell pressure to a desired value (70 kPa for the first case and 140 kPan in the second case).
6. Shear the specimen at the rate of 1%/min or 0.7 mm/min (for 70 mm sample height).
   In automated device, the software calculates it automatically based on the soil type.
7. Record ΔL, and σd in every 10 seconds (computer does it automatically).
8. Continue the test until the deviator stress shows ultimate value or 20% axial strain.
9. After completion of the test, release the cell pressure to 0, vent the pressure and bring the cell down by bring the lower platen down, drain the cell, and clean the porous stone and the assembly.
10. Sketch the mode of failure.
11. Measure the weight of the soil specimen again, and put the specimen into the oven.
12. Measure the weight again after 24 hours.
13. Repeat the test for the second specimen too (140 kPa of cell pressure and this specimen 210 kPa of cell pressure)

C	30.3kN/m^2
Φ	11.1˚

Procedure of tri-axial 4cm(0.50%)

1. Take 3 kg of soil and mix 12% of water.
2. Measure diameter, length, and initial mass of the specimen.
3. Measure the thickness of the rubber membrane.
4. Set a soil specimen in a tri-axial chamber.
5. Increase the cell pressure to a desired value (70 kPa for the first case and 140 kPa in the second case).
6. Shear the specimen at the rate of 1%/min or 0.7 mm/min (for 70 mm sample height).
   In automated device, the software calculates it automatically based on the soil type.
7. Record ΔL, and σd in every 10 seconds (computer does it automatically).
8. Continue the test until the deviator stress shows ultimate value or 20% axial strain.
9. After completion of the test, release the cell pressure to 0, vent the pressure an bring the cell down by bring the lower platen down, drain the cell, and clean the porous stone and the assembly.
10. Sketch the mode of failure.
11. Measure the weight of the soil specimen again, and put the specimen into the oven.
12. Measure the weight again after 24 hours.
13. Repeat the test for the second specimen too (140 kPa of cell pressure and third specimen 210 kPa of cell pressure)

C	29.2kN/m^2
Φ	11.9˚

Procedure of tri-axial of 4cm fiber (0.75%)

1. Take 3 kg of soil and mix 12% of water.
2. Measure diameter, length, and initial mass of the specimen.
3. Measure the thickness of the rubber membrane.
4. Set a soil specimen in a tri-axial chamber.
5. Increase the cell pressure to a desired value (70 kPa for the first case and 140 kPa in the second case).
6. Shear the specimen at the rate of 1%/min or 0.7 mm/min (for 70 mm sample height).
   In automated device, the software calculates it automatically based on the soil type.
7. Record ΔL, and σd in every 10 seconds (computer does it automatically).
8. Continue the test until the deviator stress shows ultimate value or 20% axial strain.

9. After completion of the test, release the cell pressure to 0, vent the pressure and bring the cell down by bring the lower platen down, drain the cell, and clean the porous stone and the assembly.
10. Sketch the mode of failure.
11. Measure the weight of the soil specimen again, and put the specimen into the oven.
12. Measure the weight again after 24 hours.
13. Repeat the test for the second specimen too (140 kPa of cell pressure and third Specimen 210 kPa of cell pressure)

C	28.2kN/m^2
Φ	12.2˚

RESULTS AND DISCUSSIONS

Based on the results obtained from various tests conducted on Expensive soil, Coconut fiber mixes, the variations in various engineering characteristics of the soil are discussed below- The compaction test results showed a decrease in OMC from 13.65% to 12.60 % and increase in MDD values from 1.85 g/cc to 1.90 g/cc with the addition of Coconut coir Fibre content from 0% to 25%. The soaked CBR test results indicates that the values increase from 3.9 % to 9.6 % as the Coconut coir fibre content increase from 0% to 1%.

a) With 2cm coconut fiber-

Sample	0.25%	0.50%	0.75%
C	32kN/m^2	30.5kN/m^2	29.5kN/m^2
Φ	11˚	11.8˚	12.1˚

b) For 4cm coconut fiber-

Sample	**0.25%**	**0.50%**	**0.75%**
C	30.3KN/m^2	29.2KN/m^2	28.2KN/m^2
Φ	11.1˚	11.9˚	12.2˚

CONCLUSIONS

Based on above laboratory investigations conducted on Expensive soil-Coconut coir Fibre mixes the following conclusions can be drawn: The addition of Coconut coir Fibre into the Expensive soil has changed the compaction parameters. The OMC of the Expensive soil has decreased and the maximum dry density (MDD) increased with the addition of Coconut coir Fibre. The soaked CBR values have also increased significantly with the addition of Coconut coir Fibre content. The addition of 1% Coconut coir Fibre into the Expensive soil, increase the CBR values from 3.9 % to 8.6 % From the above laboratory investigation it can be concluded that the industrial waste like Coconut coir Fibre has a potential to modify the engineering behaviour of Expensive soil and to make it suitable in many geotechnical application.

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