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Influence of coir on saturated soils using Triaxial test

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***Abstract* - Coir products are proficient for low-cost applications, especially in developing countries because of its availability at low prices compared to its synthetic counterparts. They also render the advantages of Eco friendliness and biodegradability. Even though various natural products are being tried as a reinforcement material, coir gives better performance due to its high tensile strength, stiffness, and durability. This Report evaluates the effectiveness of coir products in reinforcing soil. A systematic series of triaxial tests have been conducted to study shear strength parameters of soil reinforced with various coir products at different proportions and to determine strength and stiffness characteristics of coir reinforcement.**

***Index Terms* - reinforcing soil, triaxial tests, strength and stiffness.**

INTRODUCTION

The history explains different stories on the birth of the golden fibre.
The first recorded history of coconut in the country dates back to Ramayana period.In the Valmiki Ramayana there are references of coconut in the Kishkindha Kanda and Aranya Kanda. It is reported that Ramayana was written by Valmiki sometimes in 3rd Century BC. Generally, it is believed that coconut was introduced in India during the post-Vedic period.
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References have been made on coconut in Raghuvamsa of Kalidasa and Sangam literatures, which proves the antiquity of the coconut in India. But its origin in India remains disputed. But Marco Polo, the famous Arab traveler who visited India in the 13th Century called coconut “Indian Nut” and the logic for such a reference needs investigation by historians. Shri. P. K. Balakrishnan, a Kerala historian argues that organised coconut cultivation started in Kerala only after the arrival of the Portugese.
The history of Coir and its association with the state of Kerala dates back to the 19 th Century. Sandwiched between the Western Ghats on the east and the Arabian Sea on the west, Kerala is one of the most beautiful States in India. A tropical paradise of waving coconut palms and wide sandy beaches, this thin strip of coastal territory slopes down from the mountain ghats in a cascade of lush green vegetation and varied fauna. One of the most commonly seen tropical trees in Kerala is the Coconut tree. In fact, even the name Kerala (Kerlam in Malayalam) is derived from this tree (“Kera” in Malayalam language means Coconut and “Alam” means Land, thus Keralam = Land of Coconut). Everything from Kerala’s culture to its dishes is evolved around the Coconut tree.

Selection of Fibre for Reinforcement
Coir: Among vegetable fibres, coir has one of the highest concentrations of lignin, making it stronger but less flexible than cotton and unsuitable for dyeing. The tensile strength of coir is low compared to abaca, but it has good resistance to microbial action and saltwater damage. A coarse, short fibre extracted from the outer shell of coconuts, coir is found in ropes, mattresses, brushes, geotextiles, and automobile seats.

Coir Processing: Coir fibre is obtained from the outer layer of the fruit of coconut tree (Cocos Nucifera L). This outer layer is called the coconut husk and this husk (exocarp) of the coconut consists of a smooth waterproof outer skin (epicarp) and fibrous zone (mesocarp). The mesocarp comprises of strands of fibro-vascular bundles of coir embedded in a non-fibrous parenchymatous "corky" connective tissue usually referred to as pith, which ultimately becomes coir dust.

LITERATURE REVIEW

Many small-scale laboratory investigations have been carried out to understand the effect addition of discrete randomly distributed synthetic fiber(polypropylene or polyester) on the compressive stress-strain behavior, peak compressive strength, ductility, splitting tensile strength, and flexural toughness of fine-grained soils, and it is observed that fiber-reinforced soil performs better in all the above aspects compared to that without reinforcement (Freitag 1986, Maher and Ho 1994, Ranjan et al. 1996, Kudo et al.2001, Kumar et al. 2005, Sung-Sik 2009).

Ingold (1983) investigated, on the basis of trial studies in tri axial tests, that there loss of strength when impervious reinforcement was used with saturated clay during un drained loading, However, when permeable strengthening layers were used at closer spacing and associated by a drainage layer, there was an increase in strength even in undrained loading.

Dean (1986) experimental conducted on fiber reinforced on compacted Lean Sandy-Clay in this present investigation three fiber are used. The present investigation is conducted by using of 3 different types of fibers was used the UCS of natural and reinforced sample compacted over a wide range of water contents. From the result it concluded that the engineering properties of the soil is improved when it is compared to the raw soil

Gray and Ohashi (1983) conducted the Direct-shear test on Dry-sand reinforced by different artificial and natural fibre to calculate the results of fibre direction, fibre content, fibre area ratio and fibre stiffness. Based on the test results it is concluded that an increase in shear strength is directely proportional to the fibre area ratios.

Susan (1906) find that the by using of coir-fibre-reinforcement improved the UCS permeability and settlements properties of reinforced compacted soil samples. The coir fibre cut into a length of 25mm and mix at randomly with soil sample at different dosage of fibre amount. From the experimental the maximum flexural strength of soil increased up to 0.75% fibre dosage and decreased with further increasing dosage of the fibre content the maximum UCS are obtained at 1% fibre reinforcement and decreased with further addition of fibre content the least permeability was obtained at 0.25% of fibre reinforcement.

Jairaj (2019) a continuous reduction in MDD along with the increase in the OMC was observed for both UCF and TCF admixed in BC soil with increase in fiber content. Increase in percentage of coir fibers in both the cases reduces MDD due to fibers having smaller specific gravity compared to BC soil replace soil particles and in the case of UCF lubrication effect of adsorbed moisture by coir fiber lessens the compaction impact. The UCS of coir fiber reinforced BC soil is significantly affected by fiber content, dry density, and moisture content. Increase in fiber content decreases the dry density of compacted soil causing increase in OMC of compacted soil

Mohamad El Ahmad (2009) Drained Triaxial Response of Clay Reinforced with Natural Hemp Fibers The inclusion of hemp fibers in compacted clay improved the ductility. The addition of fibers reduced concentrated bulging and resulted in a stress-strain response that is characterized by strain hardening at axial strains exceeding 10%. The deviatoric stress at failure of fiber-reinforced specimens was larger than that of control specimens with recorded improvements of up to 60%. These improvements were found to be more pronounced in clay specimens that were compacted dry of optimum.

Suresh Praveen Kumar (2009) Maximum value of unconfined compressive strength is exhibited in the soil mix with 15% pond ash with 0.8% coir for both one day and 7 days curing. The percentage increase after one day curing is 8 and for 7 days curing is 15 for light compaction. Maximum value of CBR is obtained at OMC for 0.6% of coir and 15% of pond ash in the soil mix. The percentage increase is found to be 55 at OMC and 116 in soaked condition for light compaction. At any particular settlement, the load carrying capacity of Shedi soil-pond ash-coir mix increases with the addition of pond ash upto 15% and 0.8% coir and there after it decreases.

Hence, the following

Main objectives have been identified for the present work

1. To obtain the unconfined compressive strength of fine-grained soil specimens of size 38 mm x 76 mm, randomly reinforced with various quantities of coir fiber.
2. To obtain the stress-strain behavior of coir fiber-reinforced fine-grained soil by conducting unconsolidated undrained triaxial compression tests on 38 mm x 76-mm soil specimens.
3. To find the effect of fiber inclusion on the peak deviator stress, major principal stress at failure, shear strength parameters, and stiffness

characteristics of the soil, under the influence of confining pressure

METHODOLOGY

The two soil samples Black cotton soil (Sample A) collected from the Nandyal Road and Red soil (Sample B) collected from the Panyam village Road (Nandyal) was used in this study.

Sample A (Black cotton Soil)

The soil sample is collected from Nandyal road at Kurnool District. The sample was extracted by 50 cm deep. The soil lumps broken into small pieces and screened through 4.75mm sieve to make it free from roots, pebbles, gravel etc.

Sample B (Red Soil)

Red soil is collected from Panyam road at Kurnool district. The soil loops were broken in pieces and sieved through 4.75 mm sieve to make the soil free from all other impurities such as roots, gravel etc.

Testing

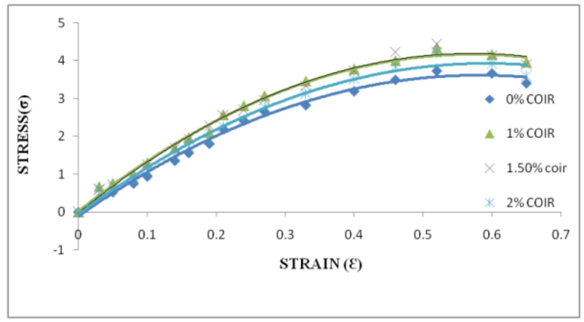
All the specimens were tested in a conventional triaxial apparatus under different confining pressures ranging from 50 to 150 kPa. Load was applied at a controlled strain rate of 1.58% minute until the specimen failed/strain of 20%, whichever was earlier. Different tests were carried out for various confining pressures, fiber contents, fiber lengths, and fiber diameters

Table:1 properties of soils

Description	Sample A	Sample B
% Gravel	2.0	4.56
% Sand	23.0	47.12
%Silt	75.43	48.32
%Clay		
Liquid limit	52	57.08
Plasticity index	34	34.05
Free swell index	130	90
Specific gravity	2.52	2.63
MDD(KN/m3)	17.3	18.45
OMC (%)	18.62	19.50
Classification of soil	CH	CH

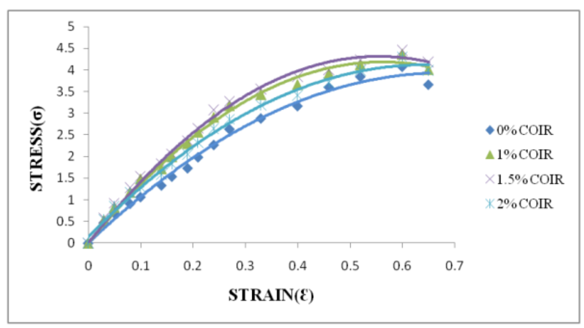
Comparitive Study on UCC values of Black soil reinforced with coir

Descriptions	UCC values of Black soil	Shear Strength values of Black soil
Black cotton soil with 0% coir	3.72 kg/cm^2	1.86 kg/cm^2
Black cotton soil with 1% coir	4.33 kg/cm^2	2.165 kg/cm^2
Black cotton soil with 1.5% coir	4.45 kg/cm^2	2.225 kg/cm^2
Black cotton soil with 2% coir	4.23 kg/cm^2	2.115 kg/cm^2



Comparitive Study on UCC values of Red soil reinforced with coir

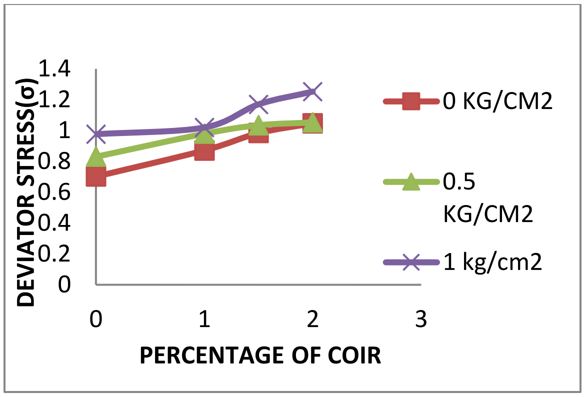
Description	UCC values of Red soil	Shear Strength values of Red soil
Red soil with 0% coir	4.08 kg/cm^2	2.04 kg/cm^2
Red soil with 1% coir	4.37 kg/cm^2	2.18kg/cm^2
Red soil with 1.5% coir	4.60 kg/cm^2	2.3 kg/cm^2
Red soil with 2% coir	4.30 kg/cm^2	2.15 kg/cm^2



Stress–Strain Response with Various Fiber Dosages

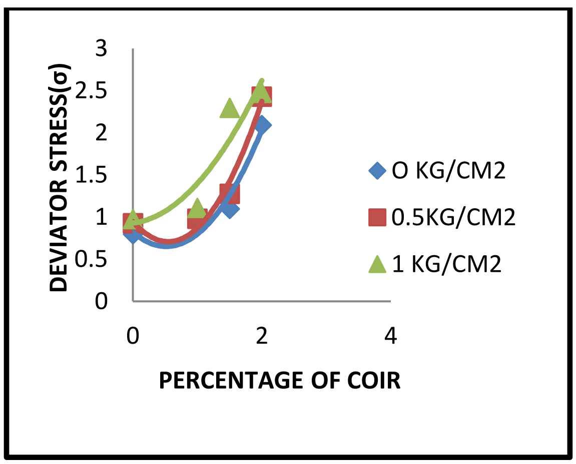
Major deviator stresses versus percentage of coir at different cell pressures for Black cotton soil

Descriptions Sample A	Cell pressure (kg/cm2)		
	0	0.5	1
0% coir	0.7013	0.8299	0.9761
1% coir	0.8709	0.9791	1.0196
1.5% coir	0.9832	1.0341	1.1697
2% coir	1.0467	1.0524	1.2523



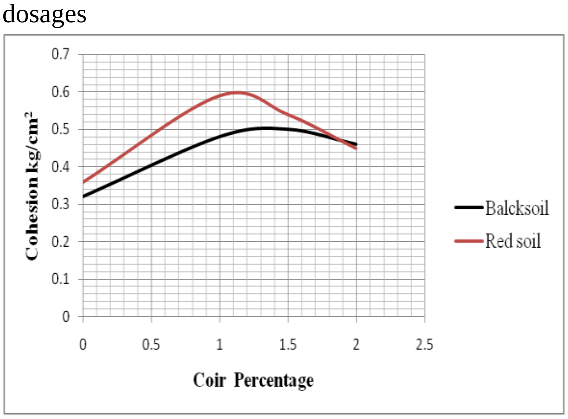
Major deviator stresses versus percentage of coir at different cell pressures for Red soil

Descriptions Sample B	Cell pressure (kg/cm²)		
	0	0.5	1
0% coir	0.8003	0.927	0.9761
1% coir	0.9167	0.9791	1.1103
1.5% coir	1.1001	1.2768	1.2768
2% coir	2.0918	2.428	2.4742

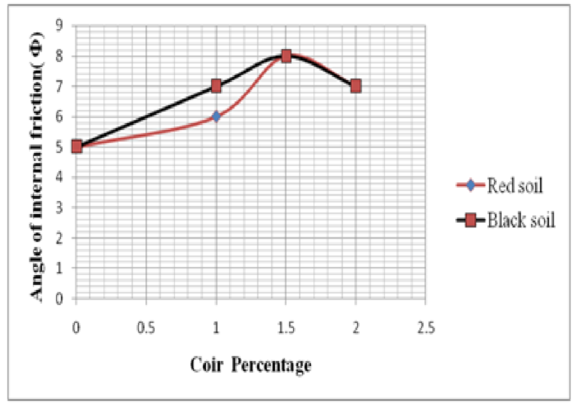


Shear Strength Parameters

Variation in cohesion of soil with various fiber dosages



Variation in friction angle of soil with various fiber dosages



Effect of Coir fiber on the Stiffness of the Soil

The stiffness modulus at a particular strain level is defined as the ratio of deviator stress to the corresponding strain. The stiffness modulus of unreinforced and coir fiber-reinforced soil are studied in a triaxial setup under UU conditions. Figures shows the variation of stiffness with axial strain for a confining pressure of 150kPa. It can be seen from the figure that reinforced specimens exhibit very high stiffness at small axial strains of the order of 2%, compared to un-reinforced specimen. With further increase in strain, there is a considerable reduction in the stiffness. After a small amount of strain is mobilized, the stiffness response is seen to be following a common trend with increase in fiber content. As the axial strain reaches around 5%, the trend is more pronounced, i.e., the stiffness is more for the soil specimen having higher fiber content. The same trend continues with further increase in axial strain. It is observed from the results that there is dramatic increase in stiffness of the fiber-reinforced specimen with increase in fiber content at low to medium strain levels. The stiffness modulus for reinforced soil with 1.5%–2%fiber content is almost double. Also, it can be understood that a large amount of stiffness is mobilized in the initial stages of strain and with further increase in strain, the stiffness values reduced noticeably. Similar trends are observed for confining pressures of 50 and 100kPa.

CONCLUSIONS

Based on the experimental observations and discussion of the test results and analysis, the following conclusions are made:

1. Shear strength parameters of un-reinforced and coir fiber reinforced soil are determined. It is observed

that high stresses are developed at 2% of coir with an increase of 25% compared to 0% of coir.

2. Addition of coir fiber in the dosage range of 1.5%–2% is found beneficial from both UCS and UU triaxial tests. With fiber dosages less than 1.5%, the improvement in strength and stiffness is not very significant. With higher fiber dosages of above 2%, the preparation of a specimen becomes difficult, and fiber shows higher tendency to agglomerate and form weak planes inside the sample.
3. The peak deviator stress and major principal stress at failure increase with increase in fiber content for all confining pressures, and fiber-reinforced soil exhibits improved ductility with increase in fiber content.
4. The cohesion and friction angle are increased significantly by the addition of coir fiber. Cohesion attains a peak value at 1.5% fiber content, and it reduces with further increase in fiber content. However, there is a steady increase in friction angle with increase in fiber content. Both cohesion and friction angles vary nonlinearly with addition of fiber.
5. The stiffness response of coir fiber-reinforced soil is better than that of un-reinforced soil. The stiffness modulus increases with increase of fiber content, and for reinforced soil with 1.5%–2% fiber content stiffness is twice compared to that of un-reinforced soil

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