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Effect of Coconut Coir Fibres on Black Cotton Soil Blended with Fly Ash

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***Abstract*: Black cotton soil is weak soil possessing undesirable engineering properties like shrinkage and swelling. Before taking up any civil engineering project on such soil, it should be improved prior to construction. Many research works have been conducted by researcher's to overcome these challenges by using different additives as stabilizers. Present study includes determination of geotechnical properties of soil collected from Chittenahalli and effectiveness of 30% fly ash and coconut fibers (0.25%, 0.5%, 0.75% & 1% by weight of solids) on strength of soil. It is found that 30% fly ash and 0.50% coconut fiber mix is optimum mix based on strength criteria.**

KeywordS: Black Cotton Soil, Fly Ash, MDD, OMC,UCS And CBR

INTRODUCTION

Urbanization in recent decades demands to take up construction of civil engineering projects even in weak soil due to land constraints. Black cotton soil is one such soil which lacks engineering properties such as shear strength and bearing capacity. In India Black soil covers about 30% of land area and is found majorly in states of Andhra Pradesh, Karnataka, Maharastra, Gujarath, Rajasthan, Uttar Pradesh, Madhya Pradesh and Tamilnadu. Therefore such soils are to be stabilized before taking up construction works. Stabilization is a process of fundamentally changing the properties of soft soils by adding binders or stabilizers, to increase the strength and stiffness of the weak soils. Stabilization leads to extra investments thereby increasing overall construction cost. Stabilization by using waste products or by products can reduce this cost and also finds the solution for waste disposal. In this study an effort of utilization of fly ash and coconut fibers are done as additives to black cotton soil.

REVIEW OF LITERATURE

Black cotton soil develops differential damages in the form of cracking, undulation, differential settlements in the embankments, buildings, irrigation canal, sewer line etc. Many researches were made to improve the strength of black cotton soil. Rajendra et al. (2013) made a review on properties of black cotton soil stabilized with fly ash varied from 0% to 50% with an increment of 10%. The researchers observed decrease in values of liquid limit and plastic limit with the addition of fly ash to BC soil. They concluded that 30% fly ash is optimum as CBR was maximum. Similar work was carriedout by Arash (2015) and he concluded that 30% fly ash-soil mix is optimum based on UCS results. Gyanen et.al (2013) determined the unconfined compressive strength of stabilized black cotton soil using fine and coarse fly ash mixture. The fly ash content was varied between 5 to 30 percent by weight of soil mass. The authors concluded that fly ash improves strength and fine fly ash leads to increase in strength of soil by 25 percent more than coarse fly ash. Singh and Arif (2014) studied behavior of clay soil stabilized with coconut fiber varied from 0% to 1% by weight of soil with an increment of 0.25%. Unsoaked and soaked CBR were 8.72% and 4.75% for plain soil and it was increased to 13.55% and 9.22% respectively when coconut fiber was 1% by weight of soil. Similar study was done by Rajan et al. (2015) for expansive soil and found that unsoaked and soaked CBR increased from 8.1% to 13.2% and 3.9% to 8.6% respectively when coconut fiber was varied at 0% and 1%. In this study an effort is made to determine an appropriate proportion of fiber content to stabilize the black cotton soil blended with flyash.

OBJECTIVES OF THE STUDY

The objectives of the present investigation are listed below

1. To evaluate the basic properties of soil.
2. To study the influence of fly ash and coconut coir on compaction characteristics of the soil.
3. To understand the effect of fly ash and coconut coir on California Bearing Ratio (CBR) and unconfined compressive strength of the soil.

EXPERIMENTAL INVESTIGATION

The materials utilized in this investigation comprise of Black cotton soil, fly ash and coir fibers.

Black cotton soil: Black cotton soil was collected from Chittenahalli Village, Piriyapatna Taluk of Mysore District. Engineering properties of black cotton soil are listed in Table 1.

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Fly ash: In this investigation Fly ash (Class F) collected from Udupi Power Corporation Ltd (UPCL), Udupi was used. The test results of fly ash are given in Table 2.

TABLE 1: Properties of black cotton soil

Specific Gravity		2.12	
Particle Size Distribution		% Gravel	0%
		% Sand	23.2%
		% Silt and Clay	76.8%
Swell Index (%)		74.07	
Liquid Limit (%)		44.5	
Plastic Limit (%)		19.5	
Plasticity Index (%)		25	
Shrinkage Limit (%)		15.42	
Classification as per IS –Medium compressible Clay (CI)			
OMC (%)		22.10	
MDD KN/m^3		15.90	
CBR Soaked (%)		2.6	
Unsoaked CBR (%)		6.8	
UCS KN/m^2	3 Days 14 days	52.2 88.9	

TABLE 2: Properties of fly ash

Specific Gravity		2.45
Fineness	As percentage residue (90µm)	3.0 %
	Blaine's surface area (m^2/kg)	350

Coconut fibers: Coconut fibers were collected from coir industries in the locality. Then fibers are to cut around length 10mm to 30mm for easy and uniform mix with soil because lengthier fibers makes the mixing and moulding difficult. Table 3 shows the physical and chemical properties of coconut fibre.

Tests Conducted

Based on literature (Rajendra et al.2013, Arash 2015) 30% fly ash content is considered as optimum in black cotton, hence the soil was initially blended with 30% fly ash and then coconut fibers are added at various proportions like 0.25%,0.5%,0.75% and 1% by weight of fly ash soil mix. Tests like Standard Proctor test, UCC and CBR are conducted to study the properties of black cotton soil.

TABLE 3: Physical and chemical properties of coconut fibers (Majjid 2010)

Physical properties		Chemical properties	
Diameter	0.1 to 0.8 mm	Lignin	20-48%
Length	60-250 mm	Hemi cellulose	15-28%
Tensile strength 15-327MPa		Cellulose	35-60%
Young's Modulus 3500 to 6000 MPa			

Optimum Moisture Content (OMC) And Maximum Dry Density (MDD)

The OMC of 30% fly ash soil blend is stabilized with various proportions of fibers are shown in Fig 1. OMC increases from 22.1% to 24.4% when coconut fiber content varies from 0% to 1%. The reason for rise in OMC is that soil may require larger quantity of water for rearranging of particle with fibers compared to the soil alone. Fig.2 shows the variations in MDD of soil mix with 30% fly ash randomly reinforced with coconut fibers. As fibers content increases from 0% to 1%, MDD decreases from 15.9kN/m^3 to 15.37kN/m^3, may be due to the addition of light weight fibers which prevent the rearranging of particles.

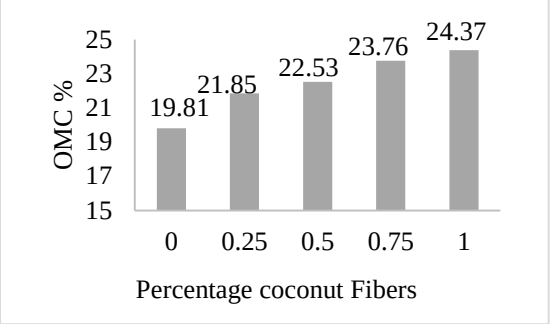

Fig. 1: Variation of OMC in 30%F.A and soil blend with fibers

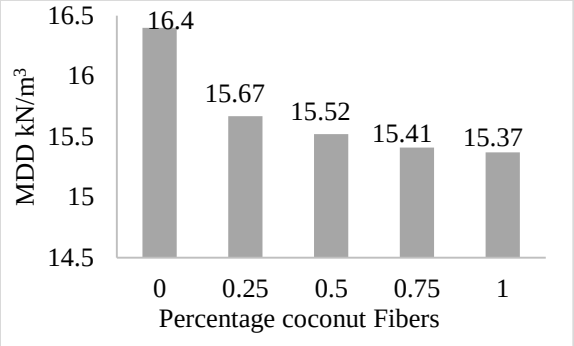

Fig. 2: Variation in MDD of 30% F.A and soil blend with fibers

Swelling and Shrinkage

Free Swell Indies of fly ash (30%) and soil mix reinforced with different dosages of fibres are determined in the laboratory. After 24hours i.e., while taking the final swell reading, floating/separation of fibers are observed and similar swell as unreinforced fly ash soil mix i.e., 42.62% is found out. With the addition of coconut fibres from 0% to 1% to soil mix with 30% fly ash, the shrinkage limit has increased from 23.13% to 32.13%.Increase in shrinkage limit with addition of fibres is because fibers restrains shrinkage of fly ash soil mix.

Unconfined Compressive Strength(UCS)

The variation of UCS values of 30% fly ash and soil blend with addition of fibers at 3 and 14 days can be observed in Fig.3. Addition of 0.5% of coconut fibers shows good improvement at 3 and 14 days of curing. Addition of fibers beyond 0.5% results in decline of UCS in both cases (3days and 14days) indicating 0.5% fiber by weight of fly ash and soil blend is an optimum fiber content. UCS increases with addition of fibers up to this limit because of the fact that the inclusion of fibers improves resistance to deformation under load by interacting of fibers with soil particles mechanically through interlocking, which in turn helps to transfer stress from soil to fibers.

The variations of cohesion and angle of internal friction (Φ) at 3 and 14 days of curing are shown in Fig. 4 and Fig.5. It is clearly observed that cohesion of 30% fly ash and soil mix increases up to 0.5% of fibers and with further addition results in decrease of value, but angle of internal

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friction increases with fibers content. Fibers are the non-cohesive materials may reduce the lubrication effect; therefore increase in addition of fibers decreases the cohesion of soil after the optimum limit. Increase in friction may be because of increased bond strength between stabilized soil and fibers.

California Bearing Ratio

The variation of soaked CBR with addition of fiber can be observed from Fig 6. Addition of coconut fibers resulted in 20.62% improvement in soaked CBR from 9.2% to 11.1% as fibers content varied from 0% to 0.5% by weight of fly ash-soil blend. Increase in CBR with addition of fibers is because addition of fibers imparts shear resistance to the soil thus it improves resistance to penetration under the loading.

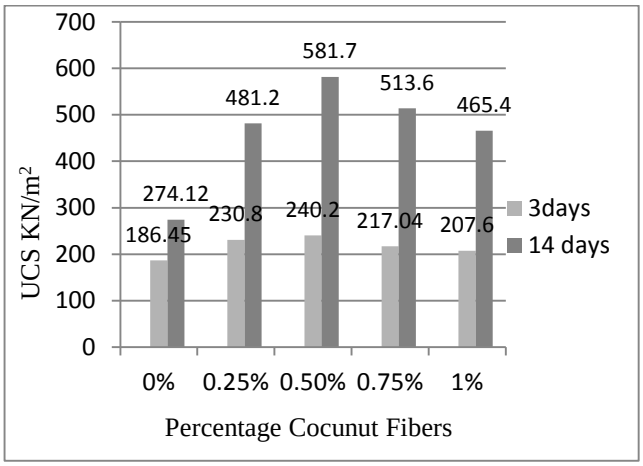

Fig.3:Variation UCS of 30%F.A and soil blend with fibers

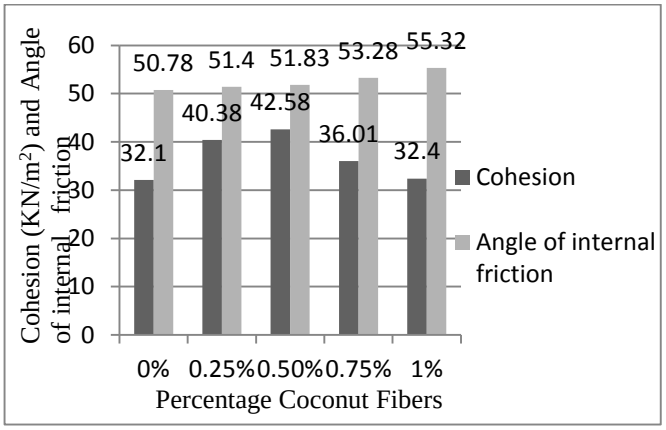

Fig.4 :Variation in C and Φ of F.A and soil with fibers at 3 days curing

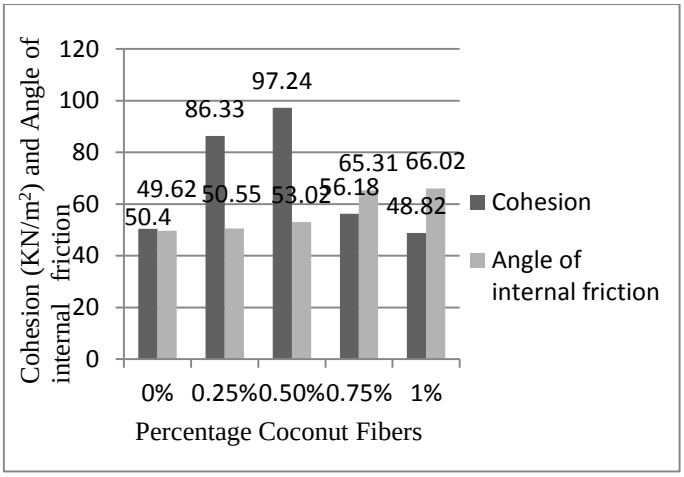

Fig. 5: Variation in C and Φ of F.A and soil with fibers at 14days of curing

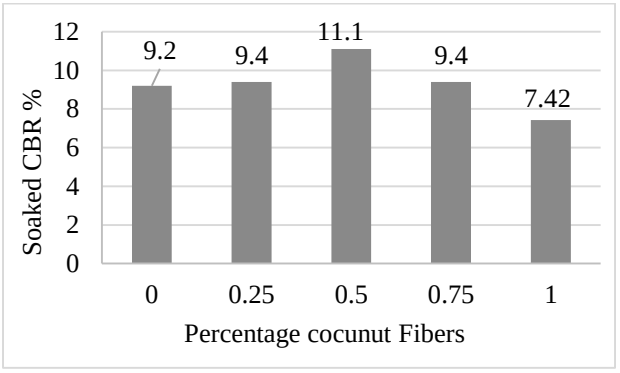

Fig.6: Variation in CBR of F.A soil blend with fibers

CONCLUSIONS

From the results of experimental investigations, following conclusions are drawn:

- The soil samples collected from the "Chittenahalli" project site are subjected to various laboratory investigations and it is noticed that it is weak therefore it demands soil stabilization.
- In 30% fly ash and soil mix as fibres content increases OMC increases from 22.1% to 24.4% in case of coconut fibers when fibers content varies from 0% to 1% and also the MDD decreases from 15.9kN/m^3 to 15.37kN/m^3.
- Addition of coconut fibers does not change the swelling properties of fly ash soil mix, but it restrains the shrinkage behavior of fly ash soil mix.
- Addition of coconut fibers to 30% fly ash and soil mix resulted in improvement of UCS from 186.45 kN/m^2 to 240.2 kN/m^2 at third day and 274.12 kN/m^2 to 581.7kN/m^2 at fourteen days of curing respectively as fibers content varies from 0% to 0.5% by weight of fly ash soil blend. Also at this fiber content the mix shows 20.62% improvement in soaked CBR.
- It can be concluded that 30% fly ash in black cotton soil with 0.5% coconut fibers is considered as the best mix to achieve the strength.

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