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Behaviour of Soil Reinforced with Plastic Waste

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***Abstract*: in this paper the study of behaviour of black cotton soil, reinforced with plastic waste is done. Various tests are performed to study the properties of soil, various percentage of plastic waste are added and results are compared with the soil without plastic waste. The results shown considerable improvement in the properties of soil.**

***Keywords*: black cotton soil, soil stabilization, soil behaviour, shear strength, plastic waste**

I. INTRODUCTION

For any land-based structure, the foundation is very important and has to be strong to support the entire structure. The soil plays a very critical role for the strong foundation. The behaviour of soils is very uncertain when it is subjected to moisture changes. These changes pose considerable challenge for the civil engineers during construction activities specially while constructing foundations. So, to work with soils, we need to have proper knowledge about their properties and factors which affect their behaviour.

Rapid improvements in the engineering world have influence a lifestyle of human beings in day to day activities of environmental life. Plastic wastes have become one of the major problems for the world. At present, population growth and developmental activities has led to the production of large amount of wastes of which non-biodegradable wastes like plastic

II. VARIOUS TEST CONDUCTED ON BLACK COTTON SOIL

The disturbed sample of Black cotton soil were collected. The sample was then sealed in plastic bags to avoid loss of moisture during transportation. The soil was air dried and then oven dried at 110°C before putting it for test. Various tests performed on this sample and following properties are found out.

Table 1. Properties of black cotton soil

Properties	Value
Specific Gravity	2.63
Liquid Limit	58%
Plastic limit	28%
liquidity index	19%
Plasticity Index	30%
Optimum Moisture Content(OMC)	22.30%
Maximum Dry Density(MDD)	15.32 KN/m^3

III.EXPERIMENTAL PROGRAM

In the experimental study, effect of addition of plastic fibre on black cotton soil was investigated and series of direct shear tests have been carried out on the soil reinforced with plastic fibre specimen including unreinforced (i.e. without plastic fibre) specimen for a different percentages of fibre content in soil.

A. Mix Ratios and Preparation of Specimen

In the present study mix ratio is defined as ratio between weight of plastic fibre and soil. Table no. 2 shows the mix ratios and weight of the material calculated for the study. The dry weight of the soil WS required to make specimen is calculated using formula Ws = $\gamma_d$max × VS,

Where $\gamma_d$max is maximum dry unit weight of soil and V_S is volume of dry soil. Volume of dry soil V_S is calculated by using the formula $V_S = V – V_F$, where V is total volume of specimen (90cc) and V_F is volume of fibers. For initial mix ratio, V_F is considered as 20 cc. Volume of water V_W to be added is calculated with respect to weight of soil ($V_W = W_S \times OMC$). Similarly, the remaining mix ratios and weight of samples were calculated. These ratios were selected based on specimen of size 6cm x 6cm x 2.5cm. The various mix ratios were calculated and according to that weight of fibre were also calculated. Figure 3.1 and figure 3.2 shows the photograph of mixing of different material and compaction of material.

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Table no. 2 Mix ratios and weight of material

Mix ratio (%)	Weight of fibre (gm)	Weight of soil (gm)	Weight of water (gm)
0.01	1.09	109.34	24.38
0.02	2.03	101.53	22.64
0.03	2.81	93.72	20.90
0.04	3.44	85.91	19.16

Figure 3.1 mixing of material

Figure 3.2 compaction of material

B Direct shear test

This test is performed to determine the shear strength of a black cotton soil. The shear strength is one of the most important engineering properties of a soil, because it is required whenever a structure is dependent on the soil's shearing resistance. The shear strength is needed for engineering situations such as determining the stability of slopes or cuts, finding the bearing capacity for foundations, and calculating the pressure exerted by a soil on a retaining wall. In this test we calculated cohesion (C) and angle of internal friction (φ) for different mix ratios.

Figure (a)

Figure (b)

Figure 3 B.1 Shear failure of (a) unreinforced and (b) reinforced material.

IV. RESULT & DISCUSSION

A. Shear Parameters

From the direct shear test data, normal stress and shear stress of the soil sample with fibre of different contents was determined. The relation between normal stress and shear stress with different mix ratios are plotted in the form of graph. The shear parameters i. e. cohesion and angle of friction were calculated from the graph. The figure 5(a) to 5(j) shows the relation between shear stress and normal stress. With increasing in mix ratio the angle of internal friction was decreased. For all mix ratios including unreinforced specimen linear relation was observed between normal stress and shear stress.

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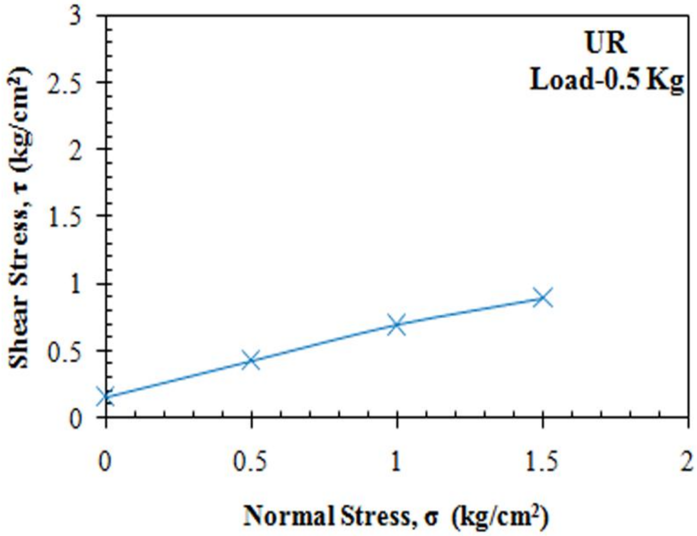
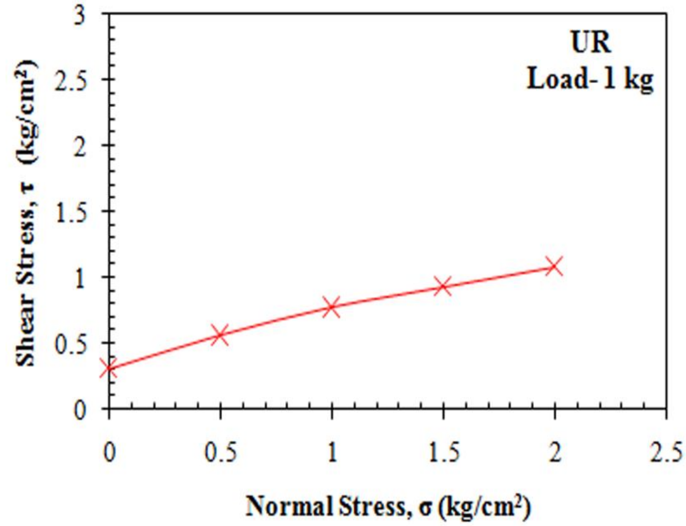


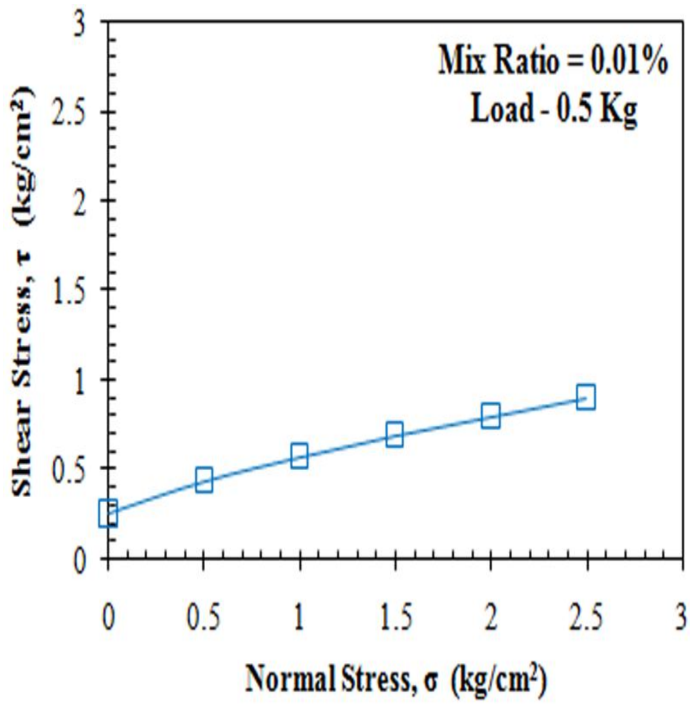
Computing from graph,
Cohesion (C) = 0.18 kg/cm2 ;
Angle of internal friction (φ) = 28.67°

Figure 5 (a)



Computing from graph,
Cohesion (C) = 0.30 kg/cm2 ;
Angle of internal friction (φ) = 26.53°

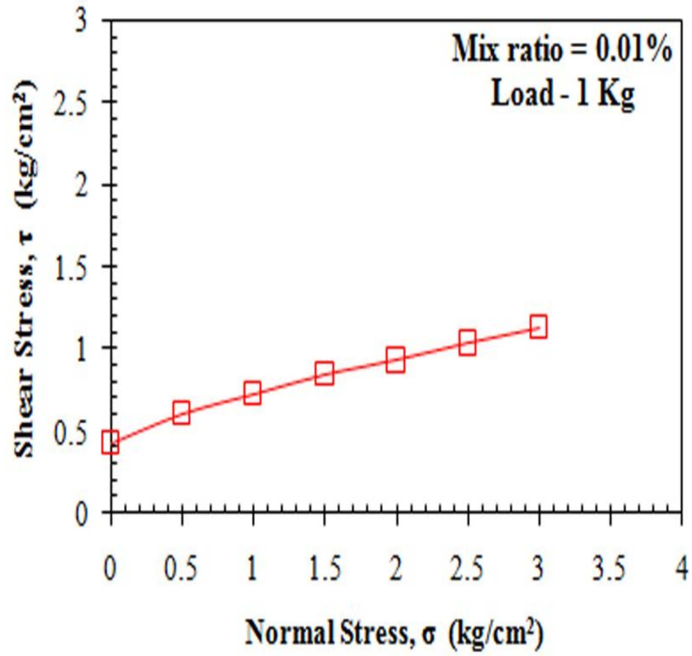
Figure 5 (b)



Computing from graph,

Cohesion (C) = 0.28 kg/cm2 ; Angle of internal friction (φ) = 20.83°

Figure 5 (c)



Computing from graph,

Cohesion (C) = 0.50 kg/cm2 ; Angle of internal friction (φ) = 19.63°

Figure 5 (d)

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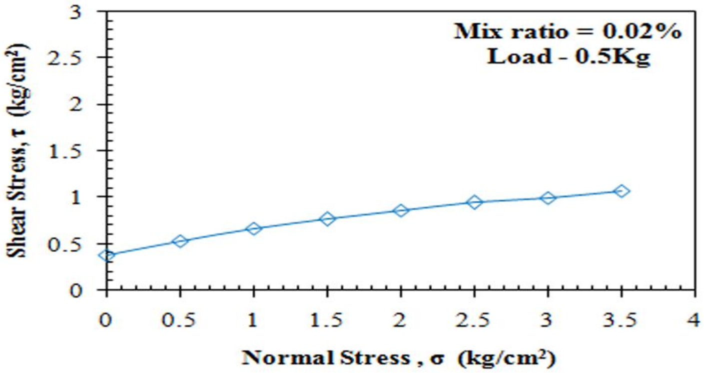
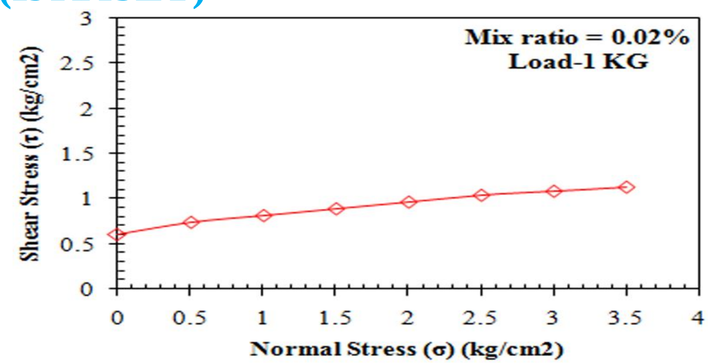


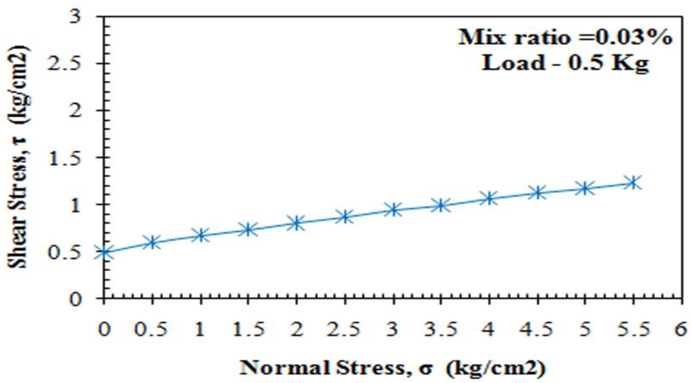
Computing from graph,
Cohesion (C) = 0.40 kg/cm2 ;
Angle of internal friction (φ) = 17.17°

Figure 5 (e)



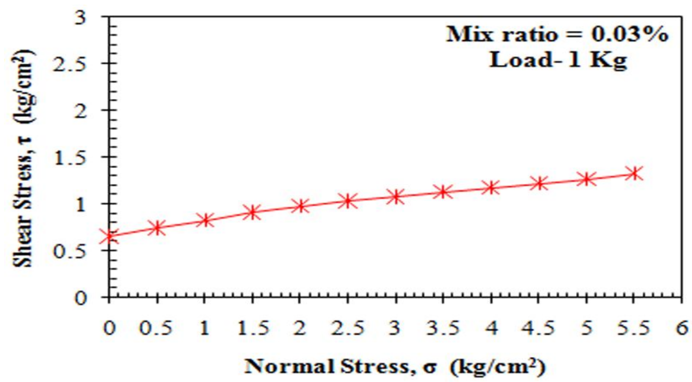
Computing from graph,
Cohesion (C) = 0.60 kg/cm2 ;
Angle of internal friction (φ) = 15.55°

Figure 5 (f)



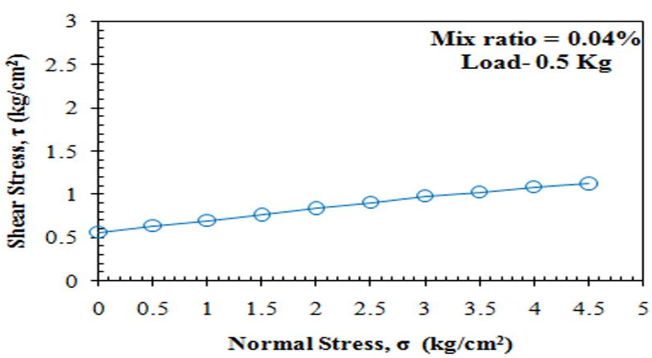
Computing from graph,
Cohesion (C) = 0.50 kg/cm2 ; Angle of internal friction (φ) = 12.07°

Figure 5 (g)



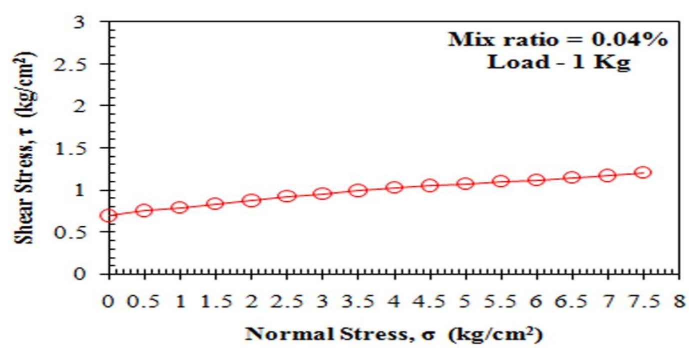
Computing from graph,
Cohesion (C) = 0.68 kg/cm2 ; Angle of internal friction (φ) = 10.77°

Figure 5 (h)



Computing from graph,
Cohesion (C) = 0.55 kg/cm2 ;
Angle of internal friction (φ) = 8.12°

Figure 5 (i)



Computing from graph,
Cohesion (C) = 0.70 kg/cm2 ;
Angle of internal friction (φ) = 6.78°

Figure 5 (j)

Figure 5 Normal stress and Shear stress for different mix ratios (a) UR, (c) 0.01%, (e) 0.02%, (g) 0.03%, (i) 0.04% for normal loaof 0.5 kg and (b) UR, (d) 0.01%, (g) 0.02%, (h) 0.03%, (j) 0.04% for normal load of 1 kg

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It was observed that for all the mix ratios including unreinforced soil sample, the cohesion were increasing with the increase of percentages of plastic fibre and angle of friction decrease with increase in fibre. The angle of friction for all mix ratios were decrease with increasing normal load i.e. 1 kg and cohesion is increased with increasing normal load.

B. Stress strain pattern

The stress-strain characteristics of the soil samples with all mix ratios and for both normal loads was determined from the shear stress data. Fig 5.2 shows the relationship between shear strain and shear stress with different mix ratios. With increasing mix ratio the stress of the specimen was increased and with the increasing normal load the stress of the specimen decreased. The shear strength of mix ratio 0.04 % has shown higher value i.e. 0.108 kg/cm2. For all mix ratios including unreinforced specimen nonlinear relationship was observed between shear strain and shear stress.

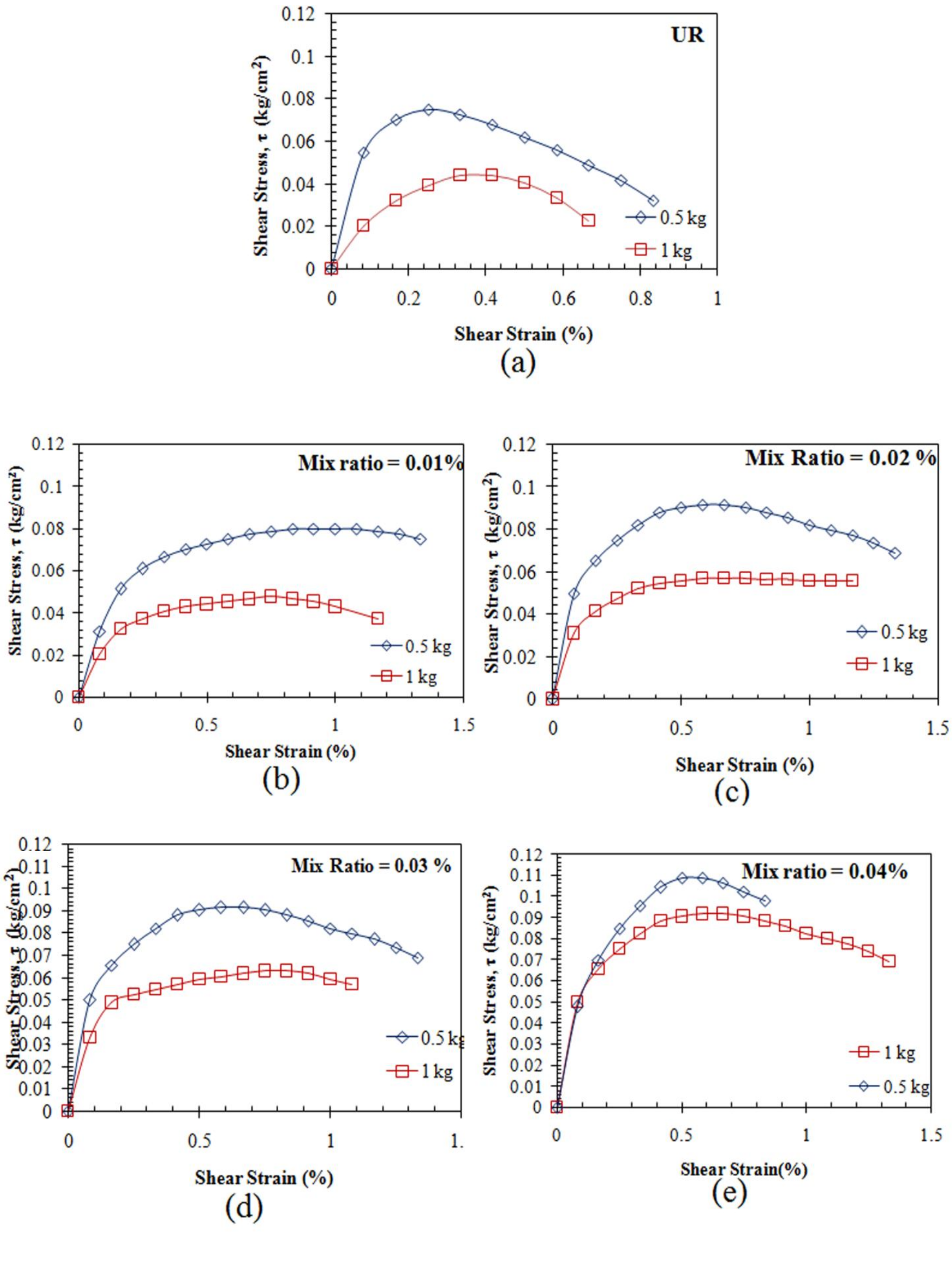

Figure 5.2 Shear strain and Shear stress for different mix ratios (a) UR, (b) 0.01%, (c) 0.02%, (d) 0.03%, (e) 0.04% for both the normal load of 0.5 kg and 1 kg

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C. Shear Strength

Shear strength is the peak value of shear stress or the failure shear stress. It can also be described the maximum point obtained on the graph of shear stress and shear strain. Table no.3 shows the values of shear strength of soil samples of all the mix ratios including unreinforced soil sample with 0.5 and 1 kg normal loadings. The maximum value of shear strength obtained was 0.108 kg/cm2 for 0.04% mix ratio with 0.5 kg loading. The minimum value of shear strength was 0.044 kg/cm2 for unreinforced soil sample with 1 kg loading.

Table No. 3 Shear Strength of the soil samples

Mix ratio (%)	Shear strength (kg/cm2)	
	0.5 kg	1 kg
UR	0.075	0.044
0.01	0.079	0.047
0.02	0.084	0.057
0.03	0.092	0.063
0.04	0.108	0.091

V. CONCLUSION

Test conducted on black cotton soil blended with polypropylene fibre lead to following conclusion:

A. The cohesion of soil for 0.5 kg loading was increased from 0.55 kg/cm2 - 0.18 kg/cm2 & for 1 kg loading was 0.70 kg/cm^2 - 0.80 kg/cm^2.

B. The angle of internal friction for 0.5 kg loading was decreased from 28.67° - 8.12° & for 1 kg loading was 26.53° - 6.78°.

C. The angle of internal friction was very low for 0.04% mix ratio and for the same ratio the cohesion value was increased. This change occur due to the inclusion of plastic fibre.

D. Appreciable increase in shear strength was observed. It increased from 0.075 kg/cm2 to 0.108 kg/cm2 and from 0.044 kg/cm^2 to 0.091 kg/cm^2 for 1 kg loading.

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