Effect of Polypropylene Fibres on Properties of Black Cotton Soil

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***Abstract*— In the present work the use of polypropylene fibers for improving properties of black cotton soil. The comparison of properties of soil with addition of varying percentages of fibers by dry weight of soil and having different aspect ratios is also carried out. The addition of polypropylene fibers resulted in increase in optimum moisture content and decrease in maximum dry density. Direct shear tests conducted on soil shows increase in value of cohesion and decrease in value of angle of internal friction. With the inclusion of the fibers increase in CBR value and unconfined compressive strength is observed.**

Keywords: **Polypropylene fibres, Aspect Ratio, Stabilisation, CBR, UCS**

I. INTRODUCTION

The usage of plastic is increasing day by day due to rapid growth of population and urbanization hence is available in huge quantity. Its fibers are simply mixed with soil to enhance the performance of soil material. This is one of the approaches to overcome the increasing amount of Plastic waste generated by the population. Recycling of Plastic is very less in comparison of its production. It is one of the major pollutant of environment as it would not decay or can't be destroyed. Inclusion of polypropylene waste comes in the category of Reinforced Earth technology of soil stabilization.

A series of laboratory tests are carried out. Polypropylene fibers are randomly mixed with soil with different aspect ratio of 3mm, 4mm and 5mm. These proportions of fibers are taken as 0.75%, 1.5%, 2.25% and 3.0% by the weight of dry soil.

II. EXPERIMENTAL WORK

Materials Used

1) Soil: The soil used in the study was the locally available black cotton soil.

2) Polypropylene fiber: The polypropylene fibers used in the study was having aspect ratio of 3mm, 4mm and 5mm. They are taken as 0.75%, 1.5%, 2.25% and 3.0% by the dry weight of soil These are obtained from dolphin float Pvt Ltd, Pune.

Table 1 Geotechnical properties of soil used in study

Sr. No.	Particulars	Values
1	Specific Gravity	2.61
2	Liquid Limit, %	57
3	Plastic Limit, %	29
4	Plasticity Index, %	28
5	OMC (%)	21.2
6	MDD, gm/cm^3	1.54
7	Cohesion (KN/m^2)	30
8	Angle of Internal friction (degree)	17
9	UCS (Kg/cm^2)	3.5

III. LABORATORY TESTS

This section describes experimental work carried out to study the behaviour of randomly distributed polypropylene fiber reinforced soil. The influence of aspect ratio and fiber concentration on the properties of soil were studied. Geotechnical properties of soil used in study are given in table 1. The fiber reinforced specimens were prepared by hand mixing the dry soil, water and polypropylene fibers. The percentage of fiber used in samples was 0.75, 1.5, 2.25 and 3 percent by dry weight of soil. The water was added prior to fiber to prevent floating problems. Fiber reinforced soil samples were prepared at the maximum dry density and the optimum moisture content obtained from standard proctor tests on reinforced soil. Undrained direct shear tests were conducted on reinforced samples with varying percentage of fibers of decided aspect ratios. CBR test is a penetration test developed by California State Highway Department for evaluating the strength of subgrade soil and base course material for flexible pavement. UCS tests were conducted on cylindrical specimen at proctors MDD and OMC

IV. RESULTS AND DISCUSSION

A) PROCTOR'S COMPACTION TEST

The OMC and dry density test results on black cotton soil with different aspect ratio and fiber content are showed in table 2 The MDD decreases with increase in the fiber content, which is due to lower density of the fiber than the soil particles. An increase in OMC was observed due to adsorption of water particles on the surface of polypropylene fibers.

Table 2 Proctor's results for un-reinforced and reinforced soil

Sr.No	Description	AR	OMC	MDD
1	S	-	21.2	1.54
2	S+0.75%PF	3	21.5	1.50
3	S+1.5%PF	3	21.88	1.47
4	S+2.25%PF	3	22.10	1.45
5	S+3.0%PF	3	21.76	1.46
6	S+0.75%PF	4	21.70	1.49
7	S+1.5%PF	4	22.20	1.45
8	S+2.25%PF	4	22.55	1.40
9	S+3.0%PF	4	21.80	1.43
10	S+0.75%PF	5	21.75	1.41
11	S+1.5%PF	5	22.30	1.34
12	S+2.25%PF	5	23.10	1.33
13	S+3.0%PF	5	22.1	1.38

B) DIRECT SHEAR TEST

Direct shear tests were conducted on soil samples in un-reinforced and reinforced conditions. The reinforcement was added in the range of 0.75%, 1.5%, 2.25% & 3.0% with varying aspect ratios of 3mm, 4mm & 5mm. It was observed that due to addition of polypropylene fibers in the soil the value of cohesion increases with increase in percent of fibers up to 2.25% and then decreases, while the angle of internal friction decreases with addition of fibers. The results obtained are summarized in table 3.

Table 3 Effect of reinforcement on shear strength of soil

Sr.No	Description	AR	Cohesion	Ø
1	S	-	30	17
2	S+0.75%PF	3	30.5	16.80
3	S+1.5%PF	3	31.65	16.40
4	S+2.25%PF	3	32.80	16.15
5	S+3.0%PF	3	31.47	16.30
6	S+0.75%PF	4	30.80	16.50
7	S+1.5%PF	4	32.65	15.85
8	S+2.25%PF	4	36.10	15.45
9	S+3.0%PF	4	35.10	15.66
10	S+0.75%PF	5	30.85	16.15
11	S+1.5%PF	5	32.85	15.55
12	S+2.25%PF	5	35.10	15.09
13	S+3.0%PF	5	34.20	15.15

C) CBR TEST

The CBR tests were conducted on unreinforced soil and soil reinforced with fiber. The tests were carried out after four days soaking in water. CBR values at different aspect ratio and varying fiber content are given in table 4. The maximum CBR value in present study was obtained for an aspect ratio of 5mm and 2.25% fiber content.

Table 4 CBR values for reinforced and unreinforced soil

Sr.No	Description	AR	CBR
1	S	-	4.8
2	S+0.75%PF	3	5.35
3	S+1.5%PF	3	5.80
4	S+2.25%PF	3	6.10
5	S+3.0%PF	3	5.75
6	S+0.75%PF	4	5.52
7	S+1.5%PF	4	6.23
8	S+2.25%PF	4	6.88
9	S+3.0%PF	4	6.20
10	S+0.75%PF	5	5.57
11	S+1.5%PF	5	6.30
12	S+2.25%PF	5	7.06
13	S+3.0%PF	5	6.25

D) UNCONFINED COMPRESSIVE STRENGTH

The maximum load that can be transmitted to the sub soil by foundation depends upon the resistance of the underlying soil to the shearing deformations or compressibility. The results of unconfined compressive strength conducted on sample aregiven in table 5. The values of qu increases with increase in fiber content.

Table 5 UCS for reinforced and un-reinforced soil sample

Sr.No	Description	AR	Q_u
1	S	-	3.5
2	S+0.75%PF	3	4.10
3	S+1.5%PF	3	4.65
4	S+2.25%PF	3	4.93
5	S+3.0%PF	3	4.60
6	S+0.75%PF	4	4.35
7	S+1.5%PF	4	4.70
8	S+2.25%PF	4	5.03
9	S+3.0%PF	4	4.75
10	S+0.75%PF	5	4.60
11	S+1.5%PF	5	4.88
12	S+2.25%PF	5	5.10
13	S+3.0%PF	5	4.92

V. CONCLUSIONS

1. Addition of PP fibers resulted in reduction in MDD in the range of 3% to 14% & Increase in OMC from 1% to 9% due to adsorption of water particles by the surface of fibers.
2. With addition of PP fibers increase in the value of cohesion was observed from 2% to 21% on addition of 2.25% of fibers. For addition of 3.0% of fibers value of cohesion decreases. By addition of PP fibers in the soil the angle of internal friction decreases by 1% to 11% up to 2.25 % addition of fibers and reverses the trend for 3% addition.
3. CBR value increases from 11% to 47% for addition up 2.25% of PP fibers and decreases afterwards. so, addition of 2.25% fibers can be considered as an optimum mix.
4. UCS value increases from 17% to 46% up to 2.25% addition of fibers. Hence it can be concluded that 2.25% addition of polypropylene fibers in the soil can be considered as an optimum mix for design purposes.

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