EFFECT OF POLYPROPYLENE FIBERS ON STRENGTH CHARACTERISTICS AND EROSION CONTROL OF SHOULDER SOIL

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Abstract

There is many factors that influence the failure of pavement; soil erosion in shoulders is one among them. Heavy rainfall regions like Dhakshin Kannada, shoulder erosion is one of the major considerations which is greatly affecting the life of road structure and also affects the road safety. In the present study the effect of addition of polypropylene fibers to the shoulder soil with different dosages are studied. Soil samples were collected from roads which are affected by shoulder erosion. A series of test were conducted to study the effect of fibers on California bearing ratio and shear strength of soil. From the test results it is observed that, the addition of polypropylene fiber to the soil with different dosage results insignificant improvement of strength properties. Hence addition of polypropylene fiber is recommended to use in stabilizing shoulder soil to reduce erosion and to ensure safety.

Keywords: *polypropylene fiber (pp),*

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1. INTRODUCTION

Road transport is most important mode also acts as feeder system for other modes transportation, a good and developed road transport improves connectivity, rapid urbanization, and economy of country. In pavement structure shoulder is one of important component which will not only add stability, but also provide resistance against intrusion of water to the subgrade. In India due to improper compaction and inadequate maintenance of shoulders road often get damaged due to heavy rainfall, in the regions like Dhakshin Kannada. Failure occurs mainly due to soil erosion of shoulder and heavy wheel load under the wet condition, where regions having steep topographical condition. By means of these reasons, rapid velocity of rain water along the road path forms ruts and depth of the ruts increases by another flow of rain water. This leads in road users keep away from the use of road shoulders, which reduces the road capacity and safety.

2. LITERATURE REVIEW

Mousa F. Attom et.al (1) studied effect of flat and crimped profiled fibers with different percentages and different aspect ratio(L/D) on shear strength parameter of sandy soil. The behavior of reinforced soil under three normal loading is tested by using direct shear test; the author observed that increase in shear strength and ductility when soil is reinforced with increase in percentage of fiber content having flat profile under three normal loading, it is also studied that varying the aspect ratio (L/D) of fibers will results in increase in shear strength and ductility of soil under three normal loadings.

Gurmel S. Ghataora et.al (2) investigated effect of randomly oriented discrete synthetic fiber inclusion on properties of soil by liquid chemical stabilization. By test the test results it is observed that inclusion of fiber in soil media repetitively decrease in dry density of soil; increase in flexural load carrying capacity and toughness and ductility of soil. It is also concluded that by treated and reinforced soil sustain issue drainage of water/runoff.

Chaosheng Tang et.al (3) conducted experimental program on the effect of randomly distributed polypropylene fiber reinforcement on strength and mechanical behavior of uncemented and cemented clayey soil. The strength parameters are evaluated by using UCS and Direct shear test and surface morphology is determined by scanning electron microscopy test (SEM). By the test results it is observed that inclusion of fibers in cemented and uncemented soil will results in increase in shear strength and combined fiber and cement possess more strength compare to sum of strength caused by individually. Fiber inclusion in soil media cause a bridge effect and this effect possess resistance against deformation of soil under loads is mainly dependent on soil grains and surface of fiber.

Jian Li et.al (4) investigates the effect of polypropylene fibers on tensile strength of soil by direct tensile test. The test results indicates very small dosage of fiber (0% to 0.2% by dry weight of soil) results in increases in tensile strength by 65.7% and failure behavior changes from brittle to ductile. It is also observed that the tensile strength of soil increase with the increases in dry density, leads to more contact between soil particles and also increase of fiber/soil

interface contact area. Tensile strength decrease in addition of water to soil it is because bonds between soil particle and interfacial mechanical interaction between fiber surface and soil matrix weakened by adding water.

Chao-sheng tang et.al (5) conducted experimental program on Tensile and Desiccation test on reinforced soil at different percentages of fibers and with dry density and water content. By the test results it is observed that fibers inclusion improve tensile strength even after failure some amount residue tensile strength carries a tensile load against the deformation. Since dry density is directly proportional to tensile strength of soil. For the different water content tensile test results in reduction in water content will improve tensile strength of soil. By the Desiccation test, results in cracks developed due to tensile load significantly decreases, it is mainly due to fibers used as reinforcement for soil.

A.S. Soganc (6) studied the effect of polypropylene fibers on stabilization of expansive soil. By using UCS, compaction (standard proctor test) and swelling tests the strength and swelling characteristics of soil evaluated. By the test results author observed that by addition of polypropylene fibers in soil results in increase in unconfined compression strength. As percentage of fibers increase decrease in maximum dry density, swelling characteristics of expansive soil decrease as the percentage of fibers increases.

Praveen Kumar et.al (7) investigate experimental field program on constructed polypropylene fiber reinforced fly ash soil sub base. Field CBR test, compaction test, UCS test, triaxial test were conducted on constructed sub base. By the compaction test results, author observed that as the fiber content increase decrease in maximum dry density of soil. By CBR test, for both soaked and unsoaked condition the CBR value increase with increase in percentage of fiber content. The stress carrying capacity of soil is more under small strain rate for fiber reinforced soil under static triaxial loadings. Unconfined compression strength increase linearly with fiber content.

S. Ayyappan et.al (8)investigated the effect of polypropylene fibers on fly ash soil mixtures. Compaction test, CBR, UCS test were carried out for evaluate strength parameters of fly ash soil. By the all test results it is observed that as the addition of fibers increase reduction in maximum dry density and optimum moisture content, increase in compressive strength and ductility of fly ash mixtures due energy absorption capacity of fibers. The relative increase in CBR values by the addition of fibers into fly ash soil.

Michele Dal Toc Casagrande et.al (9) studied the effect large displacements on polypropylene fiber reinforced bentonite by applying normal stress of 20 kpa and 400 kpa using direct shear test. By the test results it is observed that for large horizontal displacements there is increases in strength deteriorated and residual strength of both reinforced and unreinforced bentonite were similar.

3. MATERIALS AND METHODOLOGY

3.1 Soil

The soil is used in present investigation have been obtained from Dhakshin kannada region, Ujire to Belthangadi road side shoulders at a depth of 100mm which are affected by shoulder erosion. The physical properties of soil are listed in Table 1 and grain size distribution curve of shoulder soil represented in Figure 1.

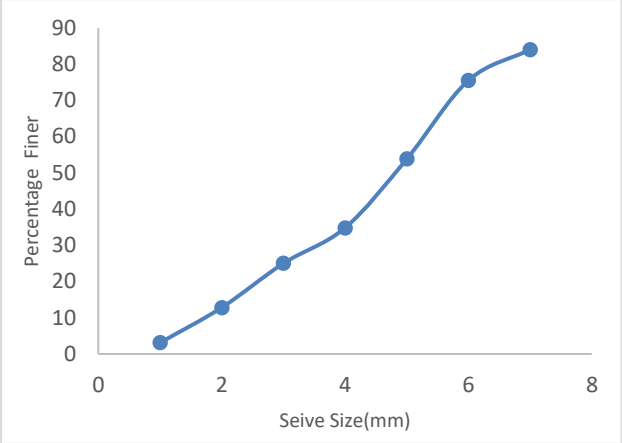

Fig 1: grain size distribution of soil

Table 1: Physical Properties of Soil.

Soil Properties	***Values***
Specific gravity	2.245
Consistency limits Liquid limit (%) Plastic limit (%) Plastic index H.R.B classification	 30.22 29.51 0.71 A-1-b
Compaction study Modified proctor test Optimum moisture content (%) Maximum dry density (g/cc)	 12 2.13
Grain size analysis D_{10} D_{30} D_{60} C_u C_c	 0.12 0.43 1.3 10.83 1.18

3.2 Fibers

The polypropylene fibers are collected from Ana Enterprises, Bangalore. The physical and mechanical strength of fibers are presented in table 2.

Table 2: Physical properties of polypropylene fiber

Sl. No.	***Properties***	***Units***	***Polypropylene***
1.	Shape		Triangular
2.	Length	mm	12

3.	Diameter	Microns	33
4.	Specific gravity		0.91
5.	Melting point	^oC	160
6.	Tensile strength	Mpa	400
7.	Elongation	%	60
8.	Young's modulus	Mpa	4000
9.	Alkaline stability		Very good

4. EXPERIMENTAL PROGRAM

4.1 Compaction Test

The modified proctor test were performed to determine the moisture content and dry density relationship according to (as per IS 2720 (Part-8) 1985). In this test the soil is compacted in a mould that has a volume of 2250cm^3. The diameter of 150mm. the soil mixed with varying amounts water and then compacted in five layers by hammer having a weight of 4.89 kg delivers 55 blows to each layer with dropping height of 450mm.

4.2 Direct Shear Test

The specimen for the shear test were conducted for 36cm^2 mould with remoulded soil sample having with MDD and OMC state of soil. The test is performed at the vertical normal stress of 0.5 kg/cm^2, 1.0 kg/cm^2, 1.5 kg/cm^2, 2.0 kg/cm^2, 2.5 kg/cm^2 in order to determine shear strength parameters (c and ø). The strain rate was 1.25mm/min. This test were conducted in accordance with IS 2720 (Part-16) 1987.

4.3 California Bearing Ratio

CBR test were conducted for a remoulded soil sample, compacted for maximum dry density and optimum moisture content obtained from modified proctor test. The soil specimens were prepared in a mould having 150mm diameter and 175 mm height. By dynamic compaction with five layers with 55 blows for each layer dropping height of 450mm with rammer weight of 4.89kg. This test were conducted in accordance with IS 2720 (Part-16) 1987.

5. RESULTS AND DISCUSSIONS

5.1 Effect of PP Fibers on Dry Density of Soil

The compaction curve for reinforced soil with different percentages of fiber (0.2%, 0.4%, and 0.6%) and unreinforced soil is shown in figure 2. by the test results it indicates that optimum moisture content does not show any changes by the addition fibers into the soil, but dry density of soil goes on decreasing as the fiber content increases. For the 0.6% of fiber mix the rate of decrease is about 1.96%. This is mainly due to the average unit weight of solids are reduces and some part of compaction energy is absorbed by fibers [2] [6].

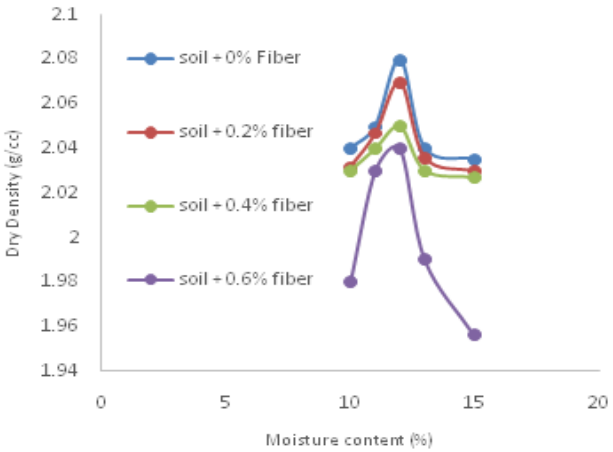

Fig 2: compaction curves for reinforced and unreinforced soil sample.

5.2 Effect of PP Fibers on California Bearing Ratio of Soil

The figure 3 shows the California bearing ratio for reinforced soil with different percentage (0.2%, 0.4%, and 0.6%) of fiber and unreinforced soil samples. By the test results, it shows as the fiber content increases from 0% to 0.6% the increase rate of CBR value is about 323%. This is mainly due to interfacial shear strength of soil and fiber matrix. The interfacial shear strength is more when increase in dry density and decreases with the increase in water content [4] [5].Table 3 represents the penetration values of unreinforced and reinforced soil specimens.

Table 3: Penetration values for reinforced and unreinforced soil.

Description	***2.5 mm Penetration (%)***	***5.0 mm Penetration (%)***
Soil + 0% fiber	7.9	7.6
Soil + 0.2% fiber	14.99	14.80
Soil + 0.4% fiber	25.33	19.6
Soil + 0.6% fiber	32.64	26.17

5.3 Effect of PP Fibers on Shear Strength of Soil

Figure no. 4 (A) (B) shows the relationship between shear parameter (c and ø) and fiber content. It is indicates that the as the fiber increases from 0% to 0.6% the angle of internal friction increase upto 39%, there is marginal increase in cohesion. Shear strength of soil mainly dependent on soil particle, and soil type.

The increase in shear strength may due to fiber come in contact in shear plane which will offers an anchoring effect of increase in frictional resistance between surrounded soil particles and fiber increase. It indicates that the fiber in shear zone tends to both suffer large plastic tensile deformation and to break [9].

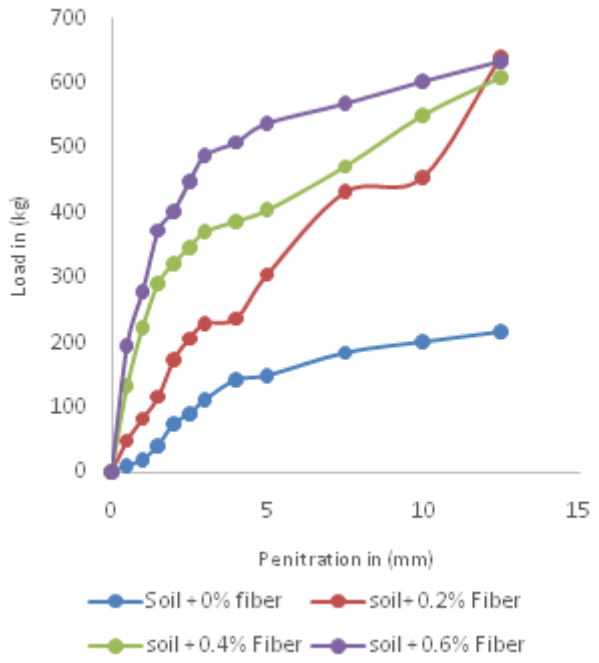

Fig 3: CBR values for reinforced and unreinforced soil sample.

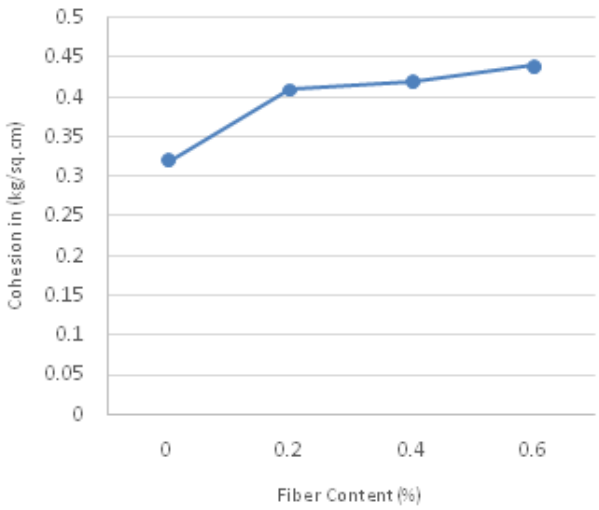

Fig 4 (a)

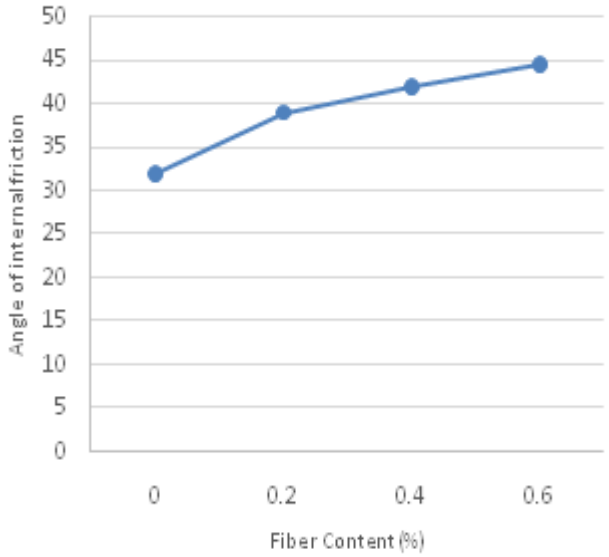

Fig 4 (b)

Fig 4: the relationship between shear strength parameters and fiber content: (a) cohesion and fiber content: (b) angle of internal friction and fiber content.

6. CONCLUSION

A series of tests were performed to study the effect of randomly distributed polypropylene fibers on strength characteristics of shoulder soil. The effect of polypropylene fibers on shear strength, California bearing ratio, dry density of soil specimen were analyzed. By the test results following conclusions can be drawn.

- Addition of pp fiber to soil results in decrease in the dry density upto 1.91% and there is no significant change in optimum moisture content is observed.
- Increase in California bearing ratio due to the addition of fibers is observed, values increases upto 413% for fiber content of 0.6%.
- As the fiber content increases, marginal increase in cohesion value is observed, and angle of internal friction increases by 39%.

By the above conclusions, it is clear that, shear strength and penetration resistance of soil increases with addition of pp fibers. Because of increase in the shear strength it may result in reduced soil erosion in shoulders. Therefore it is recommended to use pp fibers as additive in strengthening of shoulder soil in the areas which are prone to shoulder erosion.

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