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Stabilization of Soil by using Waste Fiber Materials

Y. RAMAKRISHNA REDDY[1], T. RAM PRASANNA REDDY[2]

[1]PG Scholar, Dept of Civil Engineering, Nalanda Institute of Technology, Kantepudi, Guntur (Dt), A.P, India.
[2]Professor, Dept of Civil Engineering, Nalanda Institute of Technology, Kantepudi, Guntur (Dt), A.P, India.

Abstract: The main objective of this study is to investigate the use of waste fiber materials in geotechnical applications and to evaluate the effects of waste polypropylene fibers on shear strength of unsaturated soil by carrying out direct shear tests and unconfined compression tests on two different soil samples. The results obtained are compared for the two samples and inferences are drawn towards the usability and effectiveness of fiber reinforcement as a replacement for deep foundation or raft foundation, as a cost effective approach.

Keywords: Waste Fiber Materials, Polypropylene Fibers, Fiber Reinforcement.

I. INTRODUCTION

For any land-based structure, the inspiration is incredibly important and must be robust to support the complete structure. so as for the inspiration to be robust, the soil around it plays a really essential role. So, to work with soils, we want to own correct data about their properties and factors that have an effect on their behavior. The method of soil stabilization helps to attain the specified properties in a very soil needed for the development work. From the beginning of construction work, the requirement of enhancing soil properties has come back to the sunshine.
Ancient civilizations of the Chinese, Romans and Incase used numerous strategies to boost soil strength etc., a number of these strategies were therefore effective that their buildings and roads still exist. In India, the trendy era of soil stabilization began in early 1970's, with a general Shortage of and aggregates, it became necessary for the engineers to appear at suggests that to boost soil different than replacement the poor soil at the vacant lot. Soil stabilization was used however thanks to the employment of obsolete methods and conjointly thanks to the absence of correct technique, soil stabilization lost favor. In recent times, with the rise within the demand for infrastructure, raw materials and fuel, soil stabilization has begin to take a replacement form. With the availability of higher analysis, materials and equipment, it's rising as a preferred and cost effective method for soil improvement. Here, in this project, soil stabilization has been finished the help of at random Distributed poly propylene fibers obtained from waste materials.The improvement within the shear strength parameters has been stressed upon and comparative studies have been administered mistreatment totally different strategies of shear resistance menstruation.

II. EXPERIMENTAL INVESTIGATION

Scope of Work:

- The experimental work consists of the following steps
- Specific gravity of soil
- Determination of soil index properties(Atterberg Limits)
- Liquid limit by Casagrande's apparatus
- Plastic limit
- Particle size distribution by sieve analysis
- Determination of the maximum dry density (MDD) and the corresponding content(OMC) of the soil by Proctor compaction test.
- Preparation of reinforced soil samples.
- Determination of the shear strength by:
- Direct shear test (DST)
- Unconfined compression test (UCS)

Materials:

I. Soil sample-1
II. Reinforcement: Short PP (polypropylene) fiber.

Fig1. Poly Propylene Fibers.

III. STEPS FOR MIXING OF FIBERS TO SOIL

All the soil samples are compacted at their respective Maximum Dry Density (MDD) and optimum moisture content (OMC), corresponding to the standard proctor compaction tests.

- Content of fiber in the soils are herein decided by the following equations

Where, ρf= ratio of fiber content
Wf = weight of the fiber
W = Weight of the air-dried soil

- The different values adopted in the present study for the percentage of fiber reinforcement are 0, 0.05, 0.15, and 0.25.
- In the preparation of samples, if fiber is not used then, the air-dried soil was mixed with an amount of water that depends on the OMC of the soil If fiber reinforcement was used, the adopted content of fibers was first mixed into the air-dried soil in small increments by hand, making sure that all the fibers were mixed thoroughly, so that a fairly homogenous mixture is obtained, and then the required water was added.

Table1. Index and strength parameters of PPF

Behavior parameters	Values
Fiber type	Single fiber
Unit weight	0.91 g/cm3
Average diameter	0.034 mm
Average length	12 mm
Breaking tensile strength	350 MPa
Modulus of elasticity	3500 MPa
Fusion point	1650C
Burning point	5900C
Acid and alkali resistance	Very good
Dispensability	Excellent

IV. EXPERIMENTAL TEST PROCUDURES

A. Specific gravity of the soil

The specific gravity of soil is the ratio between the weight of the soil solids and weight of equal volume of water. It is measured by the help of a volumetric flask in a very simple experimental setup where the volume of the soil is found out and its weight is divided by the weight of equal volume of water

W1- Weight of bottle in gms

W2 –weight of bottle + Dry Soil in gms.

W3-weight of bottle + Soil + Water.

W4 -Weight of bottle + Water Specific gravity is always measured in room temperature and reported to the nearest 0.1

B. Liquid limit

The Casagrande’s tool cuts a groove of size 2mm wide at the bottom and 11 mm wide at the top and 8 mm high. The number of blows used for the two soil samples to come in contact is noted down. Graph is plotted taking number of blows on a logarithmic scale on the abscissa and water content on the ordinate. Liquid limit corresponds to25 blows only.

C. Plastic limit

This is determined by rolling out soil till its diameter reaches approximately 3 mm and measuring water content for the soil, which crumbles on reaching this diameter. Plasticity index (Ip) was also calculated with the help of liquid limit and plastic limit;

$$Ip = wL – wP$$

WL-Liquid limit WP- Plastic limit.

Particle size distribution the results from sieve analysis of the soil when plotted on a semi-log graph with particle diameter or the sieve size as the abscissa with logarithmic axis and the percentage passing as the ordinate gives a clear idea about the particle size distribution. From the help of this curve, D10 and D60 are determined. This D10 is the diameter of the soil below which 10% of the soil particles lie. The ratio of, D10 and D60 gives the uniformity coefficient (Cu), which in turn is a measure of the particle size, range. 2.4.5 Proctor compaction test this experiment gives a clear relationship between the dry density of the soil and the moisture content of the soil. The experimental setup consists of

- Cylindrical metal mold (internal diameter- 10.15 command internal height-11.7 cm),
- Detachable base plate,
- Collar (5 cm effective height),
- Rammer (2.5 kg).

Compaction process helps in increasing the bulk density by driving out the air from the voids. The theory used in the experiments that for any comp active effort, the dry density depends upon the moisture content in the soil. The maximum dry density (MDD) is achieved when the soil is compacted at relatively high moisture content and almost all the air is driven out, this moisture content is called optimum moisture content (OMC). After plotting the data from the experiment with water content as the abscissa and dry density as the ordinate, we can obtain the OMCand MDD. The equations used in these Experiments as follows

D. Direct shear test

This test is used to find out the cohesion (c) and the angle of internal friction (φ) of the soil, these are the soils hear strength parameters. The shear strength is one of the most important soil properties and it is required whenever any structure depends on the soil shearing resistance. The test is conducted by putting the soil at OMC and MDD inside the shear box, which is made up of two independent parts. Constant normal load (σ) is applied to obtain one value of c and φ. Horizontal load (shearing load) is increased at a constant rate and is applied till the failure point is reached. This load when divided with the area gives the shear strength ‘τ’ for that particular normal load. The equation goes as follows:

$$\tau = c + \sigma * \tan(\varphi)$$

After repeating the experiment for different normal loads (σ) we obtain plot which is a straight line with slope equal to angle of internal friction (φ) and intercept equal to the cohesion (c). Direct shear test is the easiest and the quickest way to determine the shear strength parameters of a soil sample. The preparation of the sample is also very easy in this experiment.

V. SOIL STABILIZATION USING WASTE TIRE CORD

The fiber is derived from waste material of tire cord factory products. The main constitutive substance of this fiber is nylon 6–6. High resistance against heat, fatigue, impact, and sunlight, and high resilience are some of the valuable characteristics of this fiber, which is usually used in tire and seat belt of vehicles, fishnet, reinforced hoses, and so on. Entire cord company, quality control unit regularly tests samples of productions based on tensile strength, tensile strain at failure point, H-adhesion test, absorption percentage of resorcinol formaldehyde latex (RFL) which is used for adhesion between the interface of fiber and rubber, and hot air thermal shrinkage. The products which do not satisfy particular standards and also, some fibers which become torn in tire production process are discarded as waste products. Usually 10% of nominal production capacity of tire cord factories is waste material. Fig1 shows tire cord with 20 mm length.

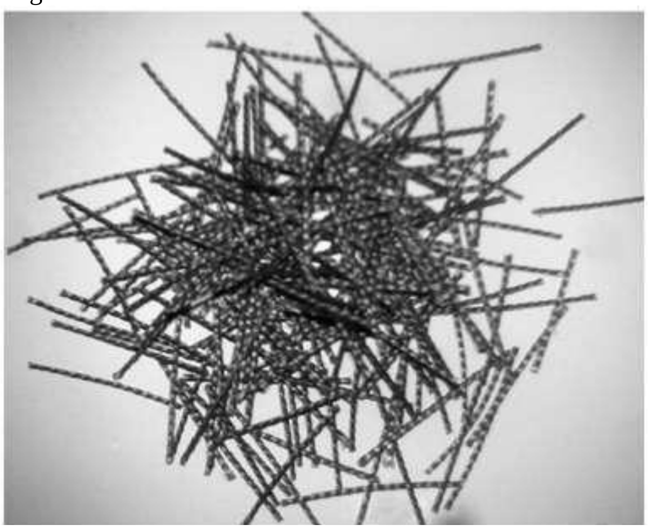

Fig.2. Tire cord with 20 mm length.

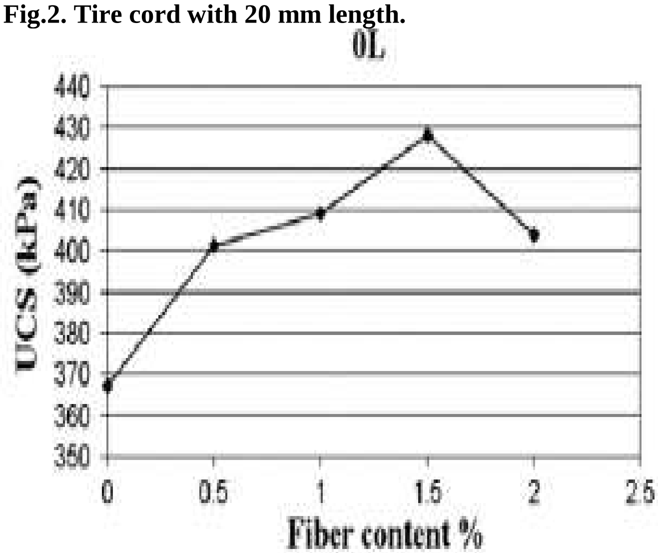

Fig.3. Unconfined compressive strength (UCS) values for unstabilized specimens versus fiber content.

Effect of fiber content on unconfined compressive strength values of unsterilized specimens is presented in Fig2.Inclusion of fiber increases the unconfined compressive strength(UCS) until 1.5%, while further values decrease it. Excessive contents of fiber increases probability of fiber agglomerating which means reduction of effective interfacial contact area between fibers and matrix. Thus, interruption of reinforcement mechanism leads to decrease of compression strength. The UCS of untreated soils 367kPa and it is increased to 428 kPa by reinforcing with1.5% fiber content

VI. RESULTS AND DISCUSSION

The tests results are summarized in Table. The variation in the Optimum moisture contents Maximum dry density, California bearing ratio, unconfined compressive strength and Differential free index are shown in Figures 1 to 3.

Table2. Summary of results

	Sample01	Sample02	Sample03
Specific Gravity Of Soil Without Fiber	3.1315	2.25	3.6042
Specific Gravity Of Soil With Fiber	3.64	2.355	3.6295
Liquid Limit Of Soil Without Fiber	41.33 %	48.15%	46.11%
Liquid Limit Of Soil With Fiber	44.89%	38%	42.40%
Plastic Limit Of Soil Without Fiber	29.68%	30.47%	30.42%
Plastic Limit Of Soil With Fiber	23.35%	29.04%	28.03%
Shrinkage Limit Of Soil Without Fiber	4.029	3.77	3.74
Shrinkage Limit Of Soil With Fiber (Ppf)	6.65	7.08	6.26

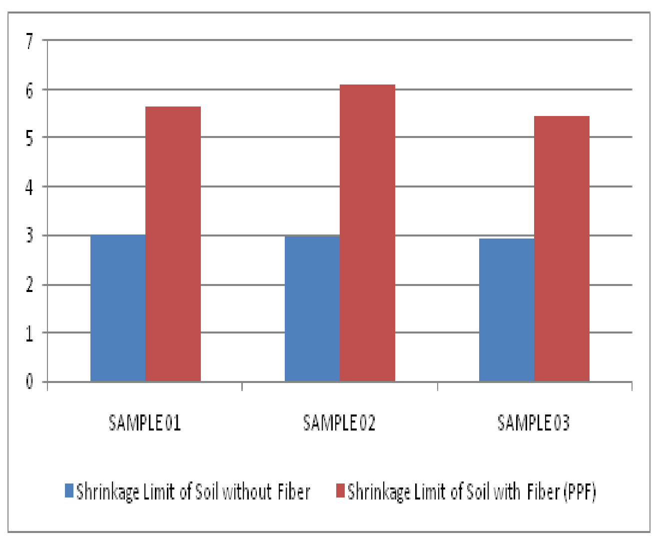

Fig4. Shrinkage Limit.

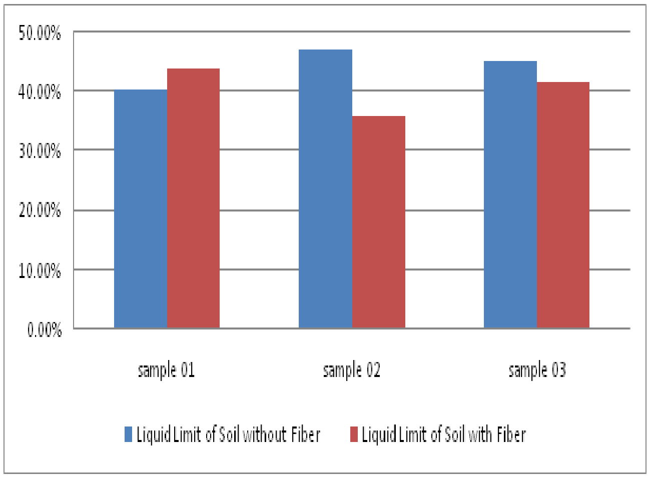

Fig5. Liquid Limit.

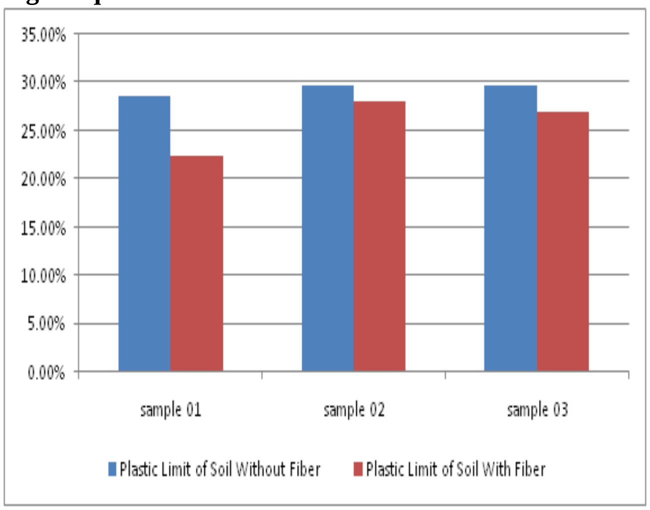

Fig6. Plastic Limit.

V. CONCLUSION

1. Supported relative density of a soil- With mixing of 0.5% fibers (PPF) relative density of the soil will increase by 0.4%. (From table no3 and 4) Strength of the soil is directly proportional to relative density; additional is that the specific gravity additional is going to be the strength of soil.
2. Supported liquid limit of a soil - Soil while not reinforcement and with reinforcement have liquid limit distinction of nighteen.19%.
3. Supported plastic limit of a soil - As the same as liquid limit the plastic limit of soil is additionally reduces. It reduces from 30.15% to 26.2%. % decrease in plastic limit is 12-tone system (From table no seven and 8), this result shows increase in shear strength Cohesiveness and consistency of soil mass.
4. Supported liquid limit of a soil - the worth of the shrinkage limit in bolstered soil is a smaller amount than that of unreinforced soil. Thus with the use of plastic fiber shrinkage reduces.
5. The worth of shrinkage limit is employed for understanding the swelling and shrinkage properties of cohesive soil. Lesser is that the shrinkage additional can the suitableness of fabric for foundation, road and mound amore are going to be the strength.

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