Soil Stabilization using Polypropylene Fiber

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Abstract—**Improvement of geotechnical properties of soil has become a common practice in construction engineering as it ultimately leads to a sufficiently strong and durable foundation which is the most important part of any construction work and this process is termed as soil stabilization This project aims at investigating the use of polypropylene fiber as a soil stabilizer and to evaluate the effect of it on different properties of soil such as UNCONFINED COMPRESSIVE STRENGTH, MAXIMUM DRY DENSITY, ATTERBERG LIMITS AND SPECIFIC GRAVITY by mixing soil sample with varying percentages of Polypropylene fiber**

Keywords-UCS, Shrinkage limit, Liquid limit, PP fiber, MDD

I. INTRODUCTION

Foundation is very important part of any civil engineering construction work. Load of any structure is ultimately taken by foundation; hence it is very necessary to prepare a sufficient strong base for any structure. For successful transfer of load of structure on the soil it is necessary to prepare soil with desirable bearing capacity. The process of soil stabilization refers to changing the physical properties of soil in order to improve its strength, durability, or other qualities. Soil stabilization is important for road construction, and other concerns related to the building and maintenance of infrastructure. Stabilization of soil is carried out by adding lime, coconut coir, fly ash, plastic fiber etc. with the soil. This project aims to conduct a study to carry out the above-mentioned process using polypropylene fiber which is basically a textile consisting of a network of natural or artificial fibers.

A. Polypropylene

Polypropylene (PP) also known as polypropene, is a thermoplastic polymer used in a wide variety of applications including packing, it is widely use in ready mix concrete and it is easily available. In synthetic fiber polypropylene is the world's second widely product after polyethylene. Chemically, polypropylene is denoted as (C3H6).

Benefits of Polypropylene Fibers :

- Polypropylene (PP) is a lightweight fiber.
- It does not absorb water. It presents that it has good resistance towards water absorb.
- Polypropylene has excellent chemical resistance. PP fibers are very resistant to most acids and alkalis.
- The thermal conductivity of this fiber is lower than that of other fibers.

B. Materials used

1)Soil

Soil used for the study is clayey soil. It has been collected from GBPUA&T Campus, Pantnagar. It is a soil of high plasticity.

2)Reinforcement

This project makes use of Polypropylene fiber and it is a synthetic material. It leads to a high rebound loss, 50-70%, which proves its use to be a cost effective approach. Length of polymer used for the following experiments is restricted to 12 mm.

Fiber Properties	Values
Specific Gravity	0.91
Density(gm/cc)	0.91
Average length(mm)	6
Average diameter(mm)	0.034

II. PREPARATION OF SAMPLE

The sample of soil is cleared of all the organic matter and waste and then, oven dried at approximately 105°C and then grounded. The different values adopted for the percentage of fiber reinforcement are 0%, 0.25%, 0.5% and 1%. The adopted content of fibers was first mixed into the air-dried soil sample 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.

A. Properties of Clayey Soil :

S.NO.	PROPERTIES	VALUE
1.	Specific Gravity(G)	2.40
2.	Density(ρ)	1.475
3.	Liquid Limit(W_L)	27.75%
4.	Optimum Moisture Content	
5.	Shrinkage Limit	18.98%
6.	Maximum Dry Density	1.64 gm/cc
7.	Unconfined Compressive Strength(q_u)	15.19 N/cm^2

III. BEHAVIOUR OF SOIL MODIFIED WITH POLYPROPYLENE FIBER

A. Modification of Atterberg Limits on Addition of PP fiber

The liquid limit of a soil is the water content at which the soil behaves practically like a liquid, but has small shear strength. It flows to close the groove in just 25 blows in Casagrande's liquid limit device.

As it is difficult to get exactly 25 blows in a test, 3 to 4 tests are conducted and the number of blows (N) required in each test is determined. A semi-log plot is then drawn between log N and the water content (w). The liquid limit is the water content corresponding to N=25, as obtained from the plot.

The shrinkage limit is the water content of the soil when the water is just sufficient to fill all the pores of the soil and the soil is just saturated. The volume of the soil does not decrease when the water content is reduced below the shrinkage limit.

$$w_s = \frac{(M_1 - M_s) - (V_1 - V_2)\rho_w}{M_s} \times 100$$

Where M_1 = initial wet mass,

V_1 = initial volume

M_s = dry mass

V_2 = volume after drying.

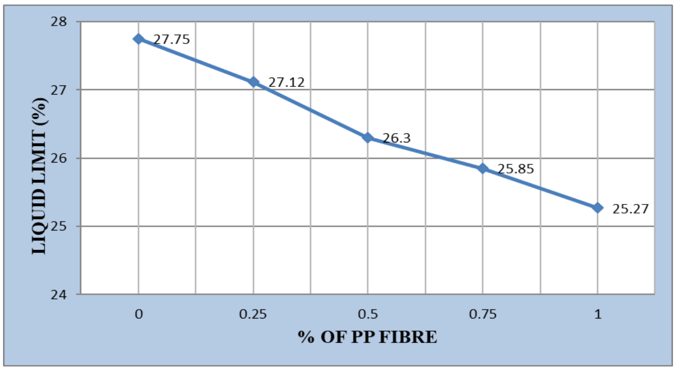

Chart – 1:Variation of Liquid Limit values with fiber content

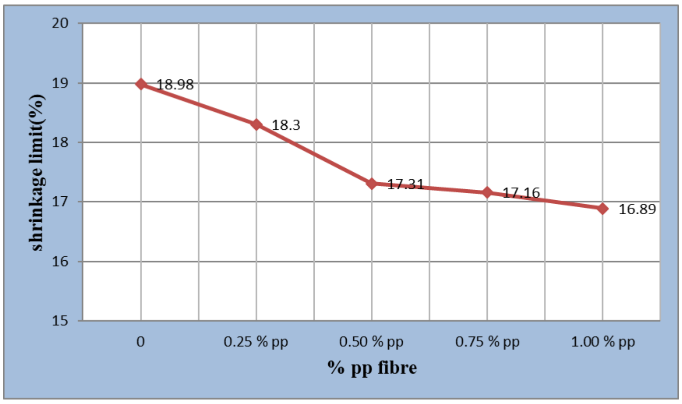

Chart – 2:Variation of Shrinkage Limit values with fiber content

Both the limits decrease gradually (LL- from 27.75% to 25.27% & SL- 18.98% to 16.89%) with increase in polymer percentage from 0 % to 1.00 %. The change may be due to repulsive nature of polymer towards water.

B. Modification of Maximum Dry Density on Addition of PP fiber

Compaction is the process of densification of soil by reducing air voids. The degree of compaction of a given soil is measured in terms of its dry density. The dry density is maximum at the optimum water content. A curve is drawn between the water content and the dry density to obtain the maximum dry density and the optimum water content.

MDD value is increasing gradually from 1.64 gm/cm3 to 1.70 gm/cm3 with increase in polymer percentage from 0% to 1.00%. For optimum value further experiments can be carried for greater percentages of PP fiber.

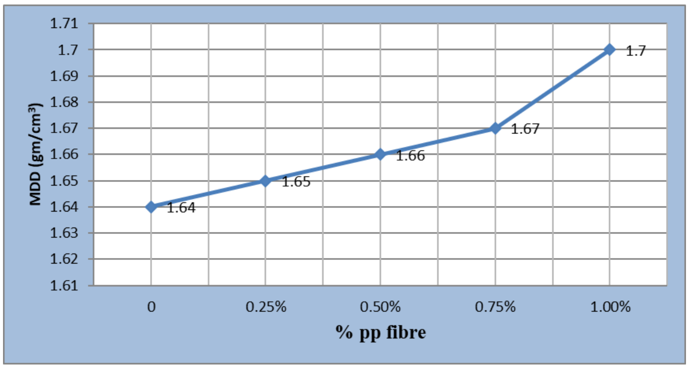

Chart – 3:Variation of MDD values with fiber content

C. Modification of UCS on Addition of PP fiber

It is not always possible to conduct the bearing capacity test in the field. Sometimes it is cheaper to take the undisturbed soil sample and test its strength in the laboratory. Also to choose the best material for the embankment, one has to conduct strength tests on the samples selected. Under these conditions it is easy to perform the unconfined compression test on undisturbed and remolded soil sample. Now we will investigate experimentally the strength of a given soil sample. UCS value is increasing gradually from 15.19 N/cm2 to 19.21 N/cm2 with increase in polymer percentage from 0% to 1.00%. This is because PP fiber acted as reinforcement to the soil. For optimum value further experiments can be carried for greater percentages of PP fiber.

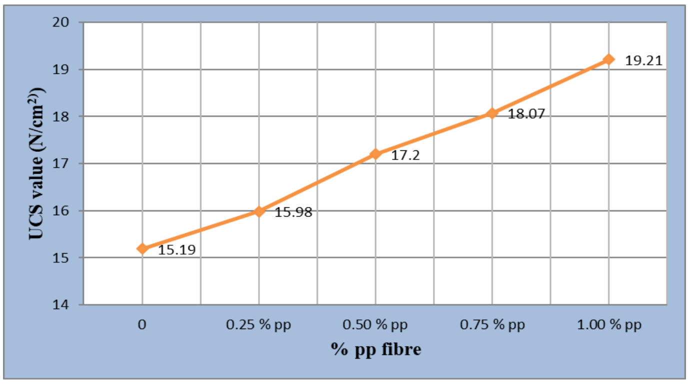

Chart – 4:Variation of UCS values with fiber content

D. Modification of Specific Gravity on Addition of PP fiber

The Pycnometer is used for determination of the specific gravity of soil particles of both fine grained and coarse grained soils. The specific gravity of soil is determined using the relation:

$$G = \frac{M_2 - M_1}{(M_2 - M_1) - (M_3 - M_4)}$$

Specific Gravity of Soil by Pycnometer

Where
M1=mass of empty Pycnometer,
M2= mass of the Pycnometer with dry soil
M3= mass of the Pycnometer and soil and water,
M4 = mass of Pycnometer filled with water only.

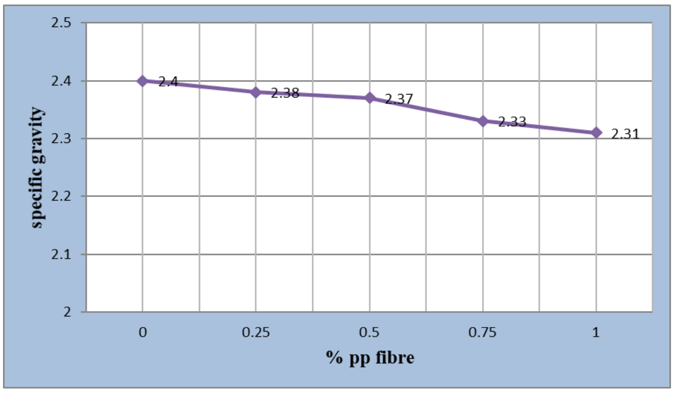

Chart – 5:Variation of Specific Gravity values with fiber content

IV. CONCLUSION

Following conclusions about mixing of the soil with PP fiber can be made from the study shown :

A. Atterberg Limits

Results obtained for different percentages of polypropylene fiber are shown in Chart 1 & 2. Both the limits decrease gradually (LL- from 27.75% to 25.27% & SL- 18.98% to 16.89%) with increase in polymer percentage from 0 % to 1.00 %. The change may be due to repulsive nature of polymer towards water.

B. Specific Gravity

Results obtained for different percentages of polypropylene fiber are shown in Chart 5. Specific gravity value is decreasing gradually from 2.4 to 2.31 with increase in polymer percentage from 0% to 1.00%.This change was due to addition of a light weight particle (PP Fiber) into the soil.

C. Maximum Dry Density

Results obtained for different percentages of polypropylene fiber are shown in Chart 3. MDD value is increasing gradually from 1.64 gm/cm3 to 1.70 gm/cm3 with increase in polymer percentage from 0% to 1.00%. For optimum value further experiments can be carried for greater percentages of PP fiber.

D. UCS Value

Results obtained for different percentages of polypropylene fiber are shown in Chart 3. MDD value is increasing gradually from 1.64 gm/cm3 to 1.70 gm/cm3 with increase in polymer percentage from 0% to 1.00%. For optimum value further experiments can be carried for greater percentages of PP fiber.

SCOPE FOR FURTHER STUDIES

Further experiments can be carried for different percentages of polypropylene fiber to achieve optimum values of the properties mentioned in this report.

REFERENCES

[1] A. Naeini and S. M. Sadjadi,(2008) ," Effect of Waste Polymer Materials on Shear Strength of Unsaturated Clays", EJGE Journal, Vol 13, Bund k,(1-12.
[2] Yetimoglu, T., Inanir, M., Inanir, O.E., 2005. A study on bearing capacity of randomly distributed fiber-reinforced sand fills overlying soft clay. Geotextiles and Geomembranes 23 (2), 174–183.
[3] Chaos Heng Tang, Bin Shi, Wei Gao, Feng Jun Chen, Yi Cai, 2006. Strength and mechanical behavior of short polypropylene fiber reinforced and cement stabilized clayey soil. Geotextiles and Geomembranes 25 (2007) 194–202.
[4] Mahmood R. Abdi, Ali Parsapajouh, and Mohammad A. Arjomand,(2008)," Effects of Random Fiber Inclusion on Consolidation, Hydraulic Conductivity, Swelling, Shrinkage Limit and Desiccation Cracking of Clays", International Journal of Civil Engineering, Vol. 6, No. 4, (284- 292).
[5] Methods of soil stabilization, December 24, 2010 [online] Available at:http://www.engineeringtraining.tpub.com/14070/css/14070_424.html.
[6] www.google.com
[7] Ground Improvement Techniques, December 18, 2008 [online] Available at: < http://www.engineeringcivil.com>
[8] Das B.M, 1992, Fundamentals of Soil Dynamics, Elsevier
[9] https://theconstructor.org