

IMPROVING THE PROPERTIES OF SOIL BY USING SYNTHETIC POLYPROPYLENE

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Abstract--- *The main objective of this study is to analyze the use of polypropylene as a waste fiber material in earthwork applications and foundation and to draw conclusion on the effect of the polypropylene fiber on shear strength of dried soil. By performing the direct shear test and unconfined compression test by taking two soil samples and after performing the test, results of both the soil samples are compared and interface are drawn so that it is easy to use effectively on substituting polypropylene fiber as a reinforcement for raft foundation or deep foundation at an acceptable cost. Polypropylene is a synthetic hydrocarbon polymer with the help of which we can increase the shrinkage, strength, ductility, etc. of soil. Many researches have been done to know the matter of randomly oriented fibers to check the behavior of soils. But very less work have been done for natural soil. Therefore, work has been done to inquire the impact of randomly oriented fiber and neatly oriented attachment on nature of soil.*

Keywords--- *polypropylene fiber(ppf), direct shear test(dst), unconfined compression test(ucs).*

1. INTRODUCTION

Structures that we construct on land, the foundation is very relevant and crucial and has to be withstanding to support the whole structure. In order for the foundation to be withstanding, the soil around it plays a very important role. So, to work with soils, we need to have correct awareness about their properties and factors which touch their behavior. The process of soil stabilization helps to attain the required properties in a soil required for the construction work. From the starting of construction work, the essential of enhancing soil properties has come to the light. Old civilizations of the Chinese, Romans and Incas utilized numerous methods to amend soil strength etc., some of these methods were so in force that their buildings and roads yet exist. In India, the modern era of soil stabilization began in early 1970's, with a universal deficit of petroleum and aggregates, it became essential for the engineers to see at ways to improve soil other than changing the poor soil at the building site. Soil stabilization was used but due to the use of outdated methods and also due to the absence of proper procedure, soil stabilization lost benefit. In present times, with the increase in the need for basins and substructures, staple materials and fuel, soil stabilization has started to take a new mode. With the handiness of better research, materials and equipment, it is emerging as a popular and cost-effective way for soil improvement.

Here, in this project, soil stabilization has been done with the help of arbitrarily distributed polypropylene fibers received from waste materials. The improvement in the shear strength parameters has been accentuated upon and comparative studies have been carried out using different ways of shear impedance measurement. Polypropylene was discovered in 1954 and gained a very much popularity with in no time due to the fact that PP has the lowest density among all other fibres. PP has an very good chemical resistivity and can be prepared through many changing methods such as moulding, injection and extrusion. Polypropylene is a polymer prepared from propylene catalytically. Its major advantage is related to the high temperature resistance which makes PP especially suitable for items such as funnels, pails, bottles, trays, car boys and Instrument jars that have to be sterilized (cleaned) commonly for use in a clinical environment. Polypropylene is a free-colour material with very good mechanical properties and it is better than polyethylene for the many reasons [1]. Polypropylene is a downstream mineral oil product that is taken from the olefin monomer propylene. The polymer is performed through a process of monomer link called addition polymerization. Heat, high-energy radiation and an initiator or a catalyst are added to combine monomers together in this process Thus, propylene molecules are polymerized into very polymer molecules or chains.

2. EXPERIMENTAL WORK AND METHODOLOGY

2.1 Experimental work

Experimental work consists of the following steps:

- (1) The Specific gravity of soil
- (2) Determining of soil index properties (Atterberg's Limits)
 - (i) Liquid limit by Casagrande's apparatus
 - (ii) Plastic limit
- (3) Particle size distribution by sieve analysis

- (4) By using standard proctor compaction test finding the maximum dry density and corresponding optimum moisture content of the soil.
- (5) Reinforced soil samples preparation.
- (6) Finding the shear strength of soil sample by:
- (i) Direct shear test (DST)
- (ii) Unconfined compression test (UCS)

2.2 Materials

- Soil sample-1
Location: behind boy's hostel block C Bgsb University
- Reinforcement: Short PP (polypropylene) fiber



Fig1. Waste pp fiber



fig.2 standard fibrillated pp fiber

The low specific gravity of polypropylene yields the greatest volume of fiber for a given weight. This means that high yield polypropylene provides better cover and bulk, while being lighter in weight. Polypropylene is the lightest fiber of all the fiber and is also lighter than water from polyester it is 34% lighter and from nylon it is 20% lighter it provides more warmth and bulk for very less weight. Water doesn't affect the strength of polypropylene fiber, whereas cotton increases in strength when wet and strength of viscose rayon falls quite markedly when wet. Polypropylene fibers resist water-borne stains better than any other fiber, because of their extremely low water absorption. As any man-made fiber, it does not attract as much dirt or dust.

Like any synthetic fiber nylon, acrylic and polyester polypropylene fibers are not attacked by micro-organism or bacteria; they are also rot-proof and moth-proof and are inherently resistant to the growth of mildew and mould. The melting point of polypropylene is about 165°C and it does not have a true softening point temperature.

2.3 Preparation of samples

For mixing of polypropylene fibre in the soil following steps are adopted-

- At their particular maximum dry density (MDD) and optimum moisture content (OMC), At their particular maximum dry density the soil samples are compacted in accordance with the standard proctor compaction tests
- Amount of fiber in the soil is adopted by the equation given below:

Where, p_f = fiber content ratio

W_f = the fiber weight

W = air-dried soil weight

In the present study for the percentage of fiber reinforcement distinct values taken are 0, 0.07, 0.12, and 0.20.

(i) In the setup of samples, if fiber is not used then, the atmospheric dried soil was combined with an amount of water that depends on the OMC of the soil.

(ii) If fiber reinforcement was used, the decided content of fibers was first mixed into the air-dried soil in small progression by hand, making sure that all the fibers were mixed effectively, so that a fairly uniform mixture is obtained, and then the needed water was added.

2.4 Brief steps involved in the experiments

2.4.1 Specific gravity of the soil

The ratio between the weight of soil solid and weight of equal volume of water is called specific gravity. specific gravity is calculated in a highly elementary manner by using a volumetric flask by finding the volume of soil and the weight of the soil is divided by the weight of the water with equal volume.

$$\text{Specific gravity} = G = \frac{m_2 - m_1}{(m_4 - m_1) - (m_3 - m_2)}$$

M1- Weight of flask in gms

M2- Weight of flask + Dry soil in gms

M3- Weight of flask + Soil + Water

M4- Weight of flask + Water

The measurement of specific gravity is always in normal temperature and is near about 0.1 in max. cases.

2.4.2 Plastic limit

This is known by wheeling out soil till its diameter touches nearly 3 mm and measuring water content for the soil which crush on obtaining this diameter. With the help of liquid limit and plastic limit Plasticity index (I_p) can also be calculated.

2.4.3 Liquid limit

The Casagrande's tool cuts a rut of size 2mm broad deep down and 11 mm wide at the upper side and 8 mm high. Note the count of strokes given to the soil sample in order to make the two samples in contact. Plotting of graph is done by taking figures of strokes on a scale of logarithm on one side and content of water on other side . from the graph liquid limit analogous to 25 strokes.

2.4.4 Particle size distribution

The idea of particle size distribution is obtained by the outcome from of the soils sieve analysis by plotting it on a semi-log graph with the sieve size or particle diameter on one side with logarithmic axis and the sieving percentage on the other side gives a clear idea about the particle size distribution. From the help of this curve, D_{10} and D_{60} are known. This D_{10} is the diameter of the soil below which 10% of the soil particles lie. The ratio of, D_{10} and D_{60} gives the uniformity coefficient (C_u) which in turn is a measure of the particle size reach

2.4.5 Proctor compaction test

A clear connection is achieved by this experiment between the dry denseness of the soil and the water content of the soil. The experimental order consists of (i) cylindrical metal shaped (internal diameter- 10.15 cm and internal height-11.7 cm), (ii) removable base plate, (iii) collar (5 cm effective height), (iv) rammer (2.5 kg). Compaction process helps in progressing the bulk density by moving out the air from the voids. The theory used in the experiment is that for any compactive deed, the dry density depends upon the moisture content in the soil. The maximum dry density (MDD) is retrieved when the soil is compacted at comparatively high moisture content and almost all the air is removed out, this moisture content is called optimum moisture content (OMC). We can obtain the OMC and MDD, by plotting the data from the experiment with water content as the abscissa and dry density as the ordinate. The terms used in this experiment are as follows:

Weight density = weight of wet soil in mould gms/volume of mould $\times 100$.

Moisture content% = weight of water gms/weight of dry soil gms $\times 100$.

Dry density = wet density / (1 + moisture content / 100)

2.4.6 Direct shear test

This test is performed to find out the cohesion (c) and the angle of internal friction (ϕ) of the soil, these are known as shear strength parameters. The shear strength is one of the most important soil properties and it is needed when so ever any structure relies on the soil shearing opposition. The test is performed by taking the soil at OMC and MDD inside the shear box which is made up of two autonomous parts. An invariant normal load (ζ) is applied to obtain one value of c and ϕ . Load parallel to earth (shearing load) is progressed at a uniform rate and applying of load is only stop when point of failure is reached. This load when divided with the area gives the shear strength ' τ ' for that specific normal load. The equation is as follows:

After repeating the experiment for distinct normal loads (ζ) we find a plot which is a straight line with slope equal to angle of internal friction (ϕ) and cut off equal to the cohesion (c). Direct shear test is the easier and the fastest way to find out the shear strength parameters of a soil sample. In this experiment the arrangement of sample is highly comfortable..

2.4.7 Unconfined compression test.

To find out the unconfined compressive strength of the soil sample this experiment is performed, and also done to calculate the shear strength of the unconsolidated and undried soil which is unconfined. The compressive stress at which the cylindrical unconfined soil sample fails under simple compressive test is the unconfined compressive strength q_u . The experimental apparatus consists of the compression device and dial gauges for load and deformation. The load was taken for distinct readings of strain dial gauge starting from $\epsilon = 0.005$ and increasing by 0.005 at each step. The rectified cross-sectional area was calculated by dividing the area by $(1 - \epsilon)$ and then the compressive stress for each step was calculated by dividing the load with the rectified area.

$$q_u = \text{load} / \text{corrected area (A')} \\ q_u - \text{compressive stress}$$

$$A' = \text{cross-sectional area} / (1 - \epsilon)$$

3. RESULTS AND DISCUSSION

The results of the tests are sum up in a table, which shows the specific gravity, liquid limit, plastic limit and shrinkage limit of soil with and without fiber.

	Sample-1	Sample-2
Soils Specific gravity without fiber	2.81	2.70
Soils Specific gravity with fiber	3.23	3.12
Liquid limit of soil without fibre	39.42	46.75
Liquid limit of soil with fibre	43.50	36.4
Plastic limit of soil without fiber	27.37	29.58
Plastic limit of soil with fiber	21.56	28.12
Shrinkage limit of soil without fiber	3.99	3.25
Shrinkage limit of soil with fiber	5.54	6.75

Comparison of shear parameters between soil sample- 1 and soil sample- 2

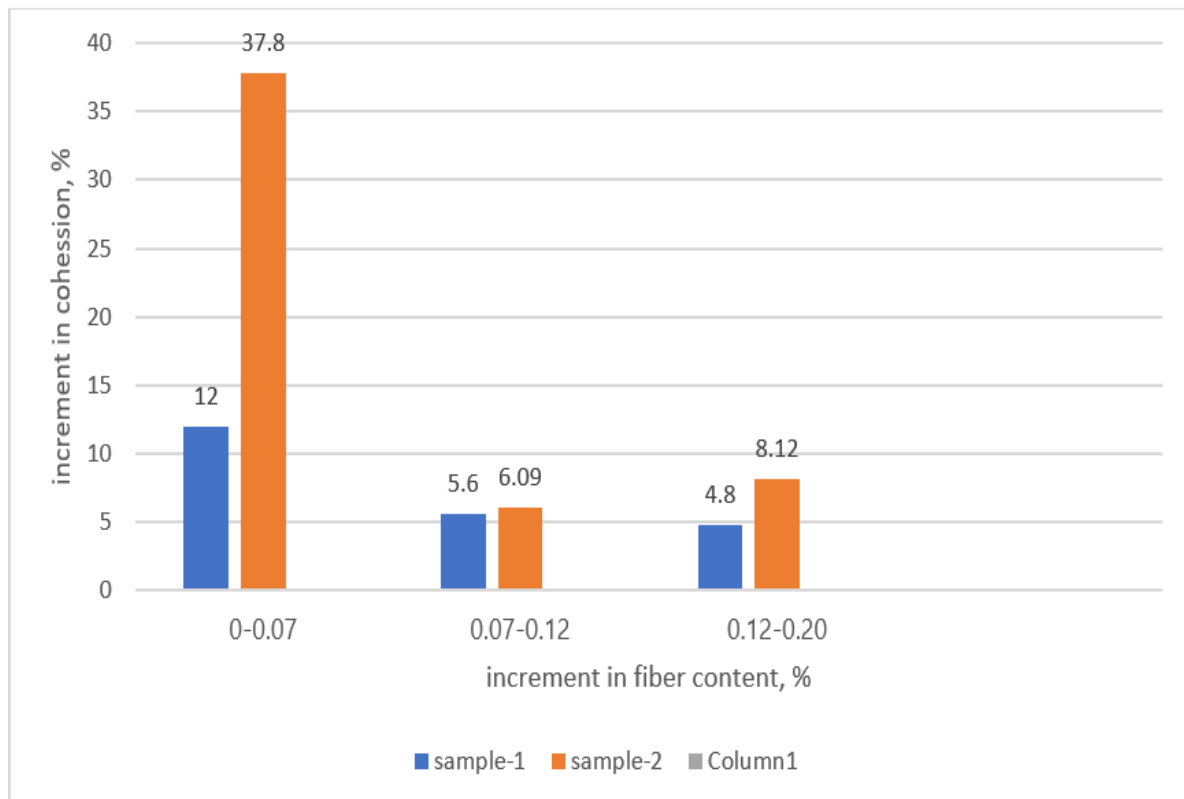


Fig-31 Comparison of cohesion values between soil sample- 1 and soil sample- 2

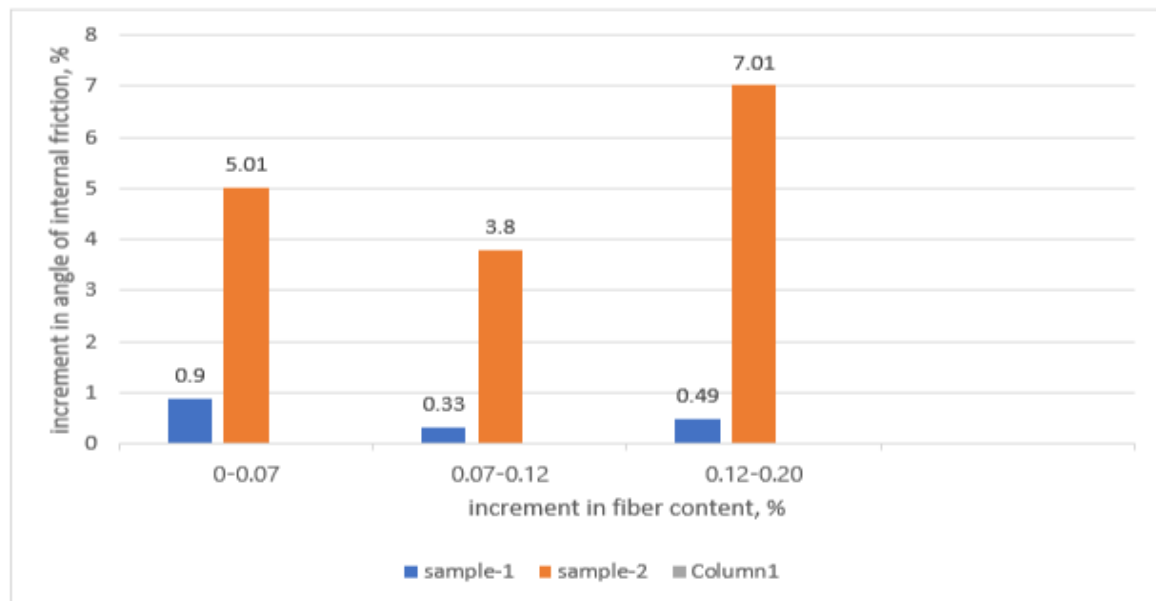


Fig-32 Comparison of ϕ values between soil sample- 1 and soil sample- 2

4. CONCLUSIONS

Cohesion value increases from 0.325 kg/cm² to 0.3892 kg/cm², a net 19.9% □ The increasing graph shows a gradual decline in grade for sample.1.

The angle of internal friction increases from 47.72 to 48.491 degrees, a net 1.60%

There is a normal increase in the strength of soil with this reinforcement..

UCS value increases from 0.0565 MPa to 0.0646 MPa, a net 14.6% for sample.1

The value of UCS rises from 0.0692 mpa to 0.1039, a net 50.1% for sample 2

With a starting abrupt slope the gradient of increasing graph is continuously reduced for soil sample.1

The increment in shear strength of soil due to reinforcement is significant for sample.2

As a result, we concluded that soil with fiber reinforcement is considered to be a good ground improvement technique particularly the engineering projects having weak soils on weak soils where it can act as a alternative to deep/raft foundations, which reduces both cost and energy

REFERENCES

- 1) S. 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. *A study on bearing capacity of orbotrarily distributed fiber-reinforced sand fills overlying soft clay. Geotextiles and Geomembranes* 23 (2), 174–183.
- 3) Chaosheng Tang, Bin Shi, Wei Gao, Fengjun Chen, Yi Cai, 2006. Strength a, Inanir, O.E., 2005. *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) Consoli, N. C., Prietto, P. D. M. and Ulbrich, L. A. (1999). “*The behavior of a fibre reinforced cemented soil.*” *Ground Improvement, London*, 3(1), 21–30.
- 7) IS2720–part(xiii)1980-87 *The need for soil stabilization*, April9,2011 by Ana [online] Available at:
< <http://www.contracostalandscaping.com/the-need-for-soil-stabilization/>>
- 8) *Methods of soil stabilization*, December 24, 2010 [online] Available at:
< http://www.engineeringtraining.tpub.com/14070/css/14070_424.htm >