EFFECT OF POLYPROPYLENE FIBRES ON EXPANSIVE SOIL

Anju.C.A, Sreelekshmi.P.B, Lekshmi.G, Kiran.K.Sajan, Swami.S.P, Tintu Raj
UKF COLLEGE OF ENGINEERING & TECHNOLOGY

Abstract—The objective of study is intended to determine the reinforcing effect of randomly distributed short polypropylene fibers on the swelling characteristics, atterberg limits and unconfined compressive strength of black cotton soil. The study focuses on effect of change of percentage fiber content on the properties of soil. Polypropylene fibers of 12 mm size with varying fibre content (f = 0%, 0.25%, 0.5%, 0.75% and 1%) were studied.

Index Terms— Polypropylene fibres, Compressive strength, Reinforcement.

1 INTRODUCTION

Expansive soils are the main cause of damages to many civil engineering structures such as spread footings, roads, highways, airport runways, and earth dams constructed with expansive soils. In the United States damage caused by expansive clays exceeds the combined average annual damage from floods, hurricanes, earthquakes, and tornadoes. Construction of the buildings and other civil structures on weak and soft soils have high risk because these type of soils have low shear strength and high compressibility.

Stabilization by chemical additives, pre-wetting, squeezing control, overloading, water content prevention are general ground improvement methods that are used to mitigate swelling problems. Swelling and shrinking behaviour of the expansive soils is caused by the montmorillonite mineral, there has been a growing interest in recent years in the influence of chemical-modification of soils which upgrades and enhances the engineering properties. The transformation of soil index properties by adding chemicals such as cement, fly ash, lime, or combination of these, often alter the physical and chemical properties of soil. Recently there is a growing attention to soil reinforcement with different types of fibers. In this experimental investigation, the aim was to study the effect of polypropylene fiber reinforcement on the improvement of physical and mechanical properties of an expansive clay deposit in Palakkad, Kerala. The most commonly used synthetic material, polypropylene fiber is used in this study. This material has been chosen due to its low cost and hydrophobic and chemically inert nature which does not absorb or react with soil moisture or leachate. PP exhibits excellent resistant to abrasion, chemicals and biological (rot) entities.

The interfacial shear resistance of fiber/soil depends primarily on the rearrangement resistance of soil particles, effective interface contact area, fiber surface roughness and soil composition. Soil improvement mainly results in increase in the shear and ultimate strength along with enhancement of other engineering properties.The experimental program was carried out on soil specimens with 0%, 0.25%, 0.5%, 0.75%, and 1% polypropylene fibre additives, and the results of unconfined compression, atterberg limits and One dimensional swell tests are discussed.

Despite the difficulties encountered in representative specimen preparation due to random distribution of fiber filaments, it is observed that there is a future prospect in the use of this environmental friendly additive soil mitigation.

2 MATERIALS AND TEST METHODS

2.1 Test materials

2.1.1 Expansive soil

The soil selected for the study is black cotton soil from kozhinjampara region in palakkad district. Owing to high initial moisture content, the soil was air dried first and then broken into pieces in the laboratory. The properties of soil are determined by standard test procedures and tabulated in Table1.

Table 1. Properties of expansive soil

Property	Value
Specific gravity	2.65
Particle size distribution	
Sand (%)	12
Silt (%)	28
Clay (%)	60
Liquid limit (%)	51
Plastic limit (%)	28.31
Shrinkage limit (%)	24
Unconfined compressive Strength(KN/M2)	27.5
Free swell index (%)	37.5

ISSN 2229-5518

2.1.2 Polypropylene fibre

For the investigation, polypropylene fibre used in the experimental work was collected from Reliance Industries Ltd., Mumbai. This material has been chosen due to its low cost and hydrophobic and chemically inert nature which does not absorb or react with soil moisture or leachate. The high melting point of 160°C, low thermal and electrical conductivities, and high ignition point of 590°C are other properties.

The length of fibres was maintained at 1.2cm and is randomly mixed with soil in varying percentages (0.25%, 0.5%, 0.75% and 1.0%) by dry weight of soil. The physical properties are shown in Table 2

Table 2. Properties of polypropylene fibre.

Property	Value
Fibre type	Single fibre
Average length	12mm
Melting point	165°C
Acid resistance	High
Alkali resistance	High
Absortion	Nil
Thermal conductivity	Low

2.2 Test methods

In this paper the effect of polypropylene fibres on strength properties of expansive soil has been evaluated. Atterberg limit test was used to determine liquid limit, plastic limit and shrinkage limit. Atterberg limits test were done with different percentages of the fibres (0.25%, 0.5%, 0.75%, and 1% of dry weight of soil). Unconfined compressive strength test and swell test were done with varying percentages of polypropylene fibres (0.25%, 0.5%, 0.75%, and 1% of dry weight of soil).

2.2.1 Sample Preparation

First of all the soil with high initial moisture content, was air dried and then crushed by a hammer then was screened through 4.75 mm size sieve. Then tests were conducted for both unreinforced and reinforced soil samples. In order to prepare polypropylene fiber reinforced specimens for atterberg limits test, at first, the soil was mixed with different water content and stir it 10 min until a homogenous mixture reached. This composite was used to estimate the liquid limit, plastic limit and shrinkage limit of recycled polypropylene fiber reinforced soil.

Unconfined compressive strength is the maximum compressive stress which a cylindrical soil sample is able to carry when its sides are not confined, used to measure the shear strength of cohesive soil reinforced with varying percentages of fibres.

2.2.2 Atterberg limits test

The liquid limit test is performed according to standard ASTMD 4318-85. Casagrande device was used to find out liquid limit for unreinforced specimen and specimen reinforced with polypropylene fibers. Plastic limit tests was conducted as per IS: 2720(part-V), 1985. Shrinkage limit tests was performed as per IS: 2720(part-VI), 1972.

2.2.3 Unconfined compressive strength test.

Unconfined compression tests using strain-controlled application of the axial load, are carried out according to the ASTM D2166-06. The unconfined compressive strength is taken as the maximum load attained per unit area or the load per unit area at 15 % axial strain, whichever is secured first during the performance of a test. The test is conducted for both fiber reinforced and unreinforced soils.

2.2.4 Swell test

To determine swell potential of the soil specimens free swell tests were held according to ASTM D4546-08. Swell starts soon after the specimen is imbibed in distilled water introduced to the cell. Displacement of the samples can be monitored by a set of dial gauges. Displacement is measured at different time intervals until the volume change is constant.
This test is conducted for varying fibre content.

3. Results and discussion

In this study various tests were conducted on soil without reinforcement and with randomly distributed discrete fiber-reinforcement. The effects of recycled polypropylene fibres on atterberglimits, swelling characertitics, and unconfinedcompressive strength tests were also studied.

3.1. Atterberg Limits Test

3.1.1. Effect of recycled polypropylene fibers on the liquid limit of soil.

The liquid limit of soil reinforced with varying fiber content is presented in fig 2. The observation of this figure indicates that with increase in fiber content the liquid limit of reinforced soil decrease. With inclusion of fiber liquid limit decreases by factors 51%, 48%, 44%, 42% and 39% respectively for fibre content of 0%, 0.25%, 0.5%, 0.75%, and 1%. Therefore, it can be concluded that random fiber inclusion seems to be a practical and effective method of increasing tensile strength of the clayey soils to resist heavy loads.

ISSN 2229-5518

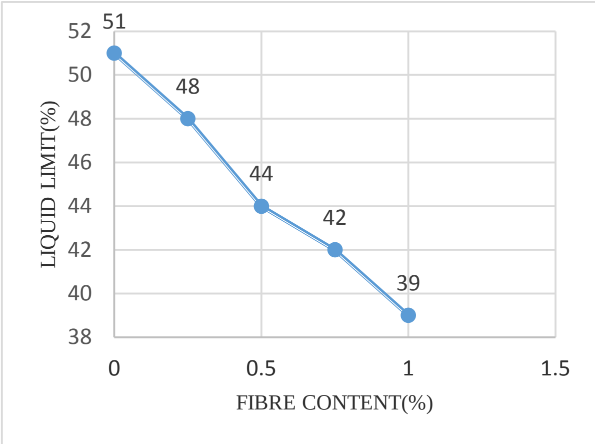

Fig1. Variation of liquid limit with fibre content

3.1.2 Effect of recycled polypropylene fibers on the plastic limit of soil.

The plastic limit of soil reinforced with varying fiber content is presented in Fig. 3. The observation of this figure indicates that with increase in fiber content the plastic limit of reinforced soil decreases.

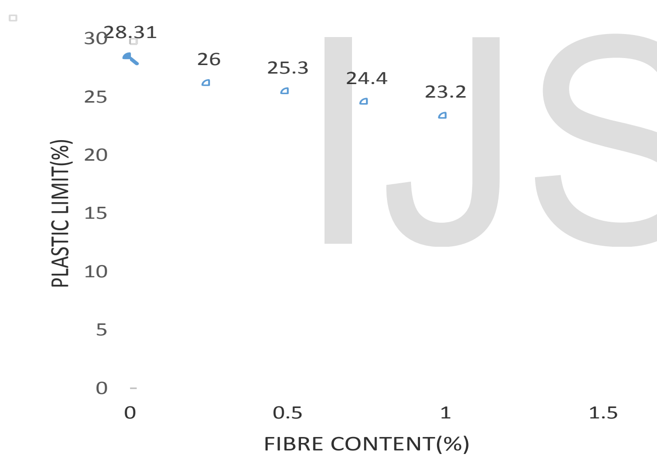

Fig 2. Variation of plastic limit with fibre content

3.1.3 Effect of recycled polypropylene fibers on the shrinkage limit of soil.

The shrinkage limit of soil reinforced with varying fiber content is presented in Fig. 4. From this figure it can be observed that with increase in fiber content the shrinkage limit of reinforced soil decreases. With inclusion of fibers, the shrinkage limit is decreased by factors 23.6, 21.2, 19.7, 17.4, 16.3 respectively for fibre content of 0%, 0.25%, 0.5%, 0.75%, and 1%.

Therefore, it can be concluded that random fiber inclusion seems to be a practical and effective method of increasing tensile strength of the clayey soils to resist volumetric changes.

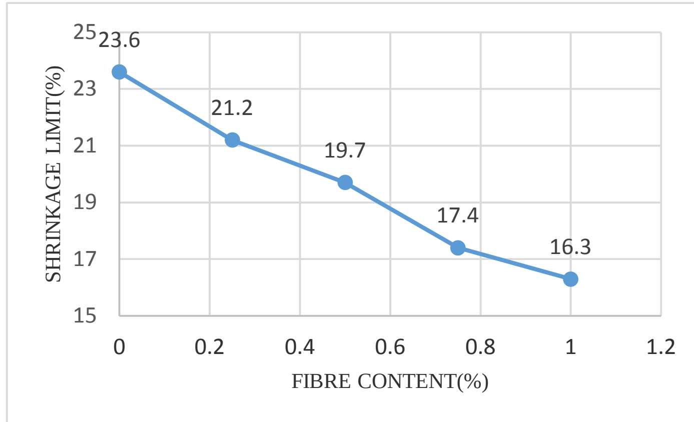

Fig 3. Variation of shrinkage limit with fibre content

3.3 Swell test

To determine swell potential of the soil specimens free swell tests were held according to ASTM D4546-08.
This test is conducted for varying fibre content and obtained that with more fibre inclusions swell index reduces.

3.4 Unconfined compressive strength test

Unconfined compression tests using strain-controlled application of the axial load, are carried out according to the ASTM D2166-06. The test is conducted for both fiber reinforced and unreinforced soils where an enhancement in unconfined compressive strength has been observed with an increase in fiber content. It is also observed that the failure of the fiber reinforced specimens occurs in longer time than the original soil, which indicates increase in the ductility of the soil after reinforcement.

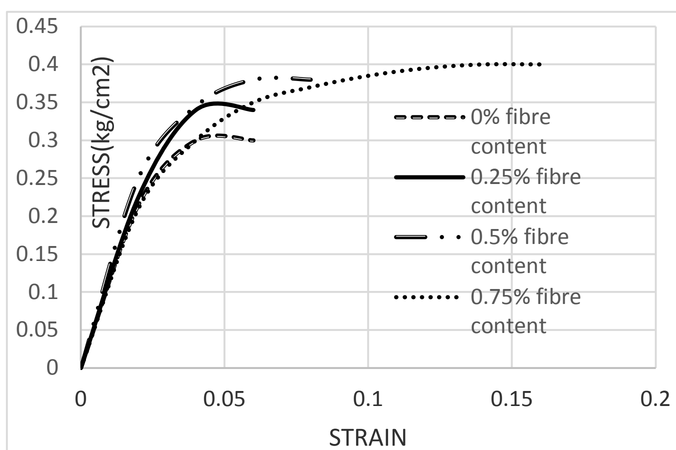

Fig 4.Stress Strain relationship of orginal and reinforced soil.

ISSN 2229-5518

4. Conclusion

In consideration of the concern over environmental pollution and cost effectiveness, soil reinforcement with fibers has been leaning towards the use of recycled fibers and locally available materials. This study investigated the effect of adding recycled polypropylene fibers on the strength behaviour of clay soil. The effects of fiber reinforcement on clayey soil were studied by using results obtained from a series of atterberg limits tests, unconfined strength tests and swell tests. Based on the results presented in this paper the following conclusions are drawn:

1. Studying the influence of polypropylene on volume change in swell-shrinkage behavior, the overall conclusion is that primary swell, time of completion of primary swell and secondary swell decrease considerably with fiber addition.

2. Fiber inclusions have improved the shrinkage properties, and hence reducing potential settlements which might occur due to environmental effects.

3. Unconfined compressive strength increased with inclusion of polypropylene fiber. Maximum unconfined compressive strength value can be observed with 0.75% fiber content, which is approximately 1.5 times of the unreinforced soil

4. On being reinforced with polypropylene fibers, liquid limit decreases as fiber content increases.

5. References

(1). Loehr., J. E., Axtell, P. J., Bowders, J. J. (2000). “Reduction of soil swell potential with fiber reinforcement”. GeoEng2000.

(2). Puppala, A.J., Musenda, C., (2002) “Effect of fibre reinforcement on strength and volume change in expansive soils”, Transportation Research Record, Paper No: 00-0716, pp. 134-140.

(3). Pradip Kumar Pradan, Rabindra Kumar, Ashutosh Naik(2010) “Effect of random inclusion of polypropylene fibres on strength characteristics of cohesive soil” Geotechnical and Geological Engineering, Vol. 30, pp. 15- 25. .

(4). Soundara, B, Senthil kumar, K. P.(2014) “Effect of Fibers on Properties of Clay”.

(5). Abhinav Nangia, Sudhir Nigam, Dharmendra Kumar, Shailendra Tiwari (2015) “Effect of Polypropylene Fibre on the Strength Characteristics of the Soils along the Yamuna River Bank in Delhi City”.