# Effect of Polypropylene Fibres on Bearing Capacity of Soil

Vaisakh M, Akhila K Paul
Thejus Engineering College, Vellarakkad
Thrissur, India

Balu Raju, Ajmal P A
Thejus Engineering College, Vellarakkad
Thrissur, India

Niranjana K
Assistant Professor
Department of Civil Engineering
Thejus Engineering College, Vellarakkad

***Abstract*— Foundation is very important in the field of civil engineering to support and resist loads of entire structure. Therefore, a foundation should be strong enough to increase the service life of any structure. The foundation of structure directly depends on to the soil. So, it is mandatory to have proper knowledge about the physical and chemical properties of soil. If the soil contains more clay content, they are usually stiff when they are dry and give up their stiffness as they become saturated. They are associated with low compressive strength and excessive settlement. This reduction in strength due to moisture content leads to severe damages to buildings and foundations. To construct building using weak or soft soil is very risky because it is sensitive to differential settlements because of its weak shear strength. When such unsuitable conditions are encountered, the only solutions are finding a new construction site, redesign the foundation, removing poor soil and replace it with suitable soil or improving engineering properties of soil. The researches regarding the effectiveness of using natural fibers are rapidly increasing. Consequently, fiber reinforced soils have recently attracted increasing attention in geotechnical engineering. In this study, an approach is followed to evaluate the bearing capacity of soil are by the addition synthetic fibers (polypropylene).**

## I. INTRODUCTION

For any land based structure, the foundation is very important and has to be strong to support the entire structure in order for the foundation to be strong, the soil around it plays a very critical role. So, to work with soils, we need to have proper knowledge about their properties and factors which affect their behavior. Some soils are not suitable for supporting structures such as buildings, bridges, highways, and dams. If the buildings are constructed on the poor soil, many problems will occur after the construction finish. It will have crack because of the settlement of the soil. The building settlement usually occur by the movement of the soil which caused by the surcharge or change of ground water table. If the settlement doesn't stop moving, the wall cracks will become bigger and the building will suddenly begin to exhibit movement without any reason. Preventing settlement problems begins with the recognition of the soil for a foundation rest, recognize the differences among soil types, determine the solution for the soils that respond to building loads and identify potential problems.

The expansive soil undergoes volumetric changes with the change in moisture content. Swelling and shrinkage of the soil causes severe damage to the foundations, buildings, roads, retaining structures etc. The need of enhancing soil properties had came in light at the beginning of ancient constructions. In ancient times, Romans utilized various methods to improve soil properties. Some of these methods were so effective that their construction in buildings and road still exist. The primary purpose of reinforcing a soil mass is to improve its stability by increasing its bearing capacity, and by reducing settlement and lateral deformation. In recent days it has been investigated that the addition of fibers will improve the ductility behavior of soil. In this study, an approach is followed to evaluate the bearing capacity of soil as by the addition of synthetic fibers (polypropylene).

## II. OBJECTIVE & SCOPE

- To investigate the possibility of polypropylene fiber as a reinforcing material in the soil
- Comparison of compaction characteristics and unconfined compressive strength of soil by the addition of (coir fibers) and synthetic fibers (polypropylene fibers)
- Evaluate the bearing capacity of the soil as by the additionof polypropylene fibers

## III. METHODOLOGY

### A. COLLECTION OF SOIL SAMPLE & MATERIALS

The materials used for the project work are locally available soil, coir fibers and polypropylene fibers.

The soil sample was collected from Killimangalam, Chelakkara, Thrissur, Kerala. It was collected at a depth of 1m from the ground surface so as to avoid the unwanted materials in top soil such as leaves, debris, plant roots, etc.

The natural coir fibers used for this study are gathered from Chembukkavu, Thrissur, Kerala.

The polypropylene fibers are collected from the online store India Mart

B. DETERMINATION OF PROPERTIES OF SOILSAMPLE

All the properties of the collected soil sample is determined as per the IS code.

Index properties of the soil sample which is to be determinedare:-

- Water content (IS; 2720-Part II-1973)
- Specific gravity (IS: 2720-Part III-1980)
- Liquid limit (IS: 2720-Part V-1985)
- Plastic limit (IS: 2720-Part V-1985)
- Shrinkage limit (IS: 2720-Part VI-1972)
- Particle size distribution (IS: 2720-Part IV-1985)
- Free swell index (IS: 2720-Part XL-1985)

Engineering properties of the soil sample which is to be determined are:-

- Light compaction test (IS: 2720-Part VII-1980)
- Unconfined compressive strength test (IS: 2720-Part X-1991

C. ADDITION OF POLYPROPYLENE TO THE SOIL SAMPLE AND DETERMINE ITS ENGINEERING PROPERTIES

A. In the soil sample, polypropylene fibers are added at different percentages such as .5%, 1%, 1.5% and conduct different tests to determine its properties. The tests are to be conducted are:-

- Light compaction test (IS: 2720-Part VII-1980)
- Unconfined compressive strength test (IS: 2720-Part X- 1991)

D. EVALUATE THE BEARING CAPACITY OF THE SOIL BY THE ADDITION OF POLYPROPYLENE FIBERS

## IV. RESULTS AND DISCUSSIONS

The tests to determine the geotechnical properties of soil weredone as per relevant IS code.

Geotechnical Properties of Soil

The index properties and engineering properties was determined and are presented in the following table.

Table 1-Geotechnical Properties of Soil

| PROPERTIES | VALUES |
|---|---|
| SPECIFIC GRAVITY | 2.7 |
| WATER CONTENT | 19.05% |
| SIEVE ANALYSIS | Percentage Gravel=4%<br>Percentage Sand=40%<br>Percentage Fine=56% |
| FREE SWELL INDEX | 0% |
| LIQUID LIMIT | 38% |
| PLASTIC LIMIT | 22% |
| SHRINKAGE LIMIT | 19% |
| SOIL TYPE | CI (Clay with intermediate plasticity) |
| MAX DRY DENSITY | 1.63g/cc |
| OPT MOISTURE CONTENT | 13.4% |
| UNCONFINED COMPRESSIVE STRENGTH | 37.26 kN/m² |

From UCC test it is clear that soil has soft consistency.

## V EFFECT OF POLYPROPYLENE FIBERS ON COMPACTION CHARECTERISTICS OF SOIL

Compaction characteristics were studied by conducting light compaction tests as per the IS: 2720-Part VII-1980. The tests were carried out on the soil samples containing 0%, 0.5%, 1%, 1.5% ,etc. of polypropylene fibers having a length of 24 mm in order to determine the maximum dry density and optimum moisture content.

- 0.5% polypropylene fibers

As by adding 0.5% fibers to the soil, the light compaction test is conducted as per IS 2720- Part VII-1980. Then the results were plotted graphically as by taking water content as X-axis and dry density/saturated dry density as Y-axis.

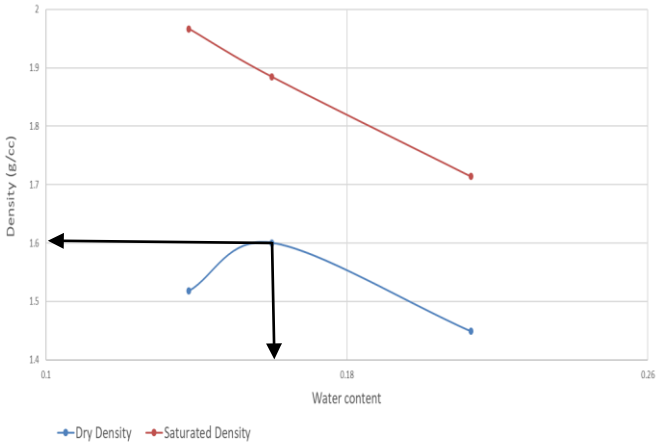


Fig 1- Compaction curve of 0.5% polypropylene fibers on soil From the graph, the dry density will be increases up to a

limit and then decreases which shows the compaction curve. This curve reveals that the maximum dry density is obtained as

1.6 g/cc and optimum moisture content as 16%.

- 1% polypropylene fibers

As by adding 1 % fibers to the soil, the light compaction test is conducted as per IS 2720- Part VII-1980. Then the results were plotted graphically as by taking water content as X-axis and dry density/saturated dry density as Y-axis.

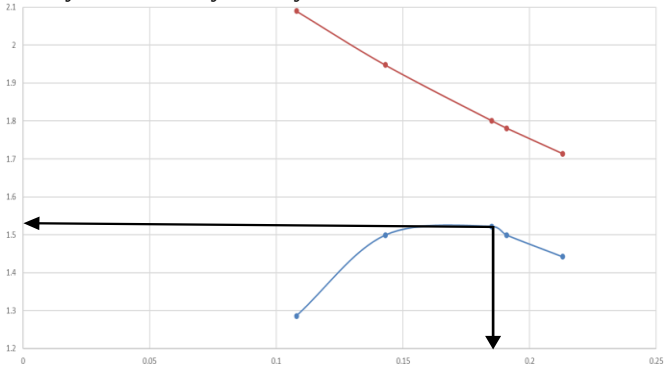

Fig 2- Compaction curve of 1% polypropylene fibers on soil

From the graph, the dry density will be increases up to a limit and then decreases which shows the compaction curve. This curve reveals that the maximum dry density is obtained as
1.53 g/cc and optimum moisture content as 17.4 %.

- 1.5% polypropylene fibers

As by adding 1.5 % fibers to the soil, the light compaction test is conducted as per IS 2720- Part VII-1980. Then the results were plotted graphically as by taking water content as X-axis and dry density/saturated dry density as Y-axis.

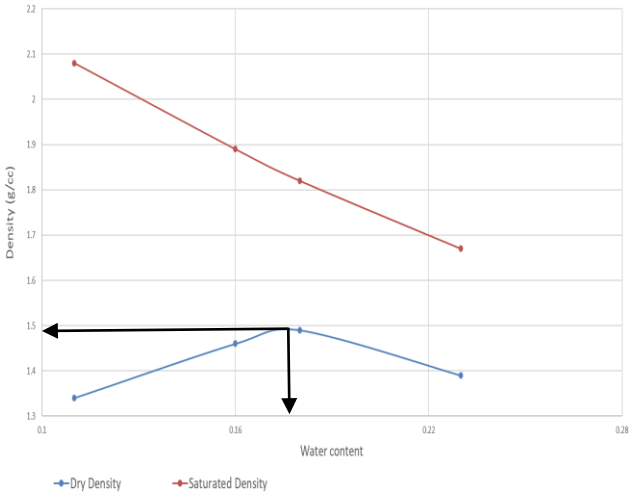


Fig 3- Compaction curve of 1.5% polypropylene fibers on soilFrom the result, the dry density will be increases up to a
limit and then decreases which shows the compaction curve. This curve reveals that the maximum dry density is obtained as 1.49 g/cc and optimum moisture content as 18 %.

As by the addition of polypropylene fibers in different percentages to the soil the variation in the maximum dry density is evaluated. The maximum dry density (MDD) will be decreasing and optimum moisture content (OMC) will be increasing as by the increase in the percentage of the polypropylene fibers to the soil. [1]

## VI EFFECT OF POLYPROPYLENE FIBERS ON UNCONFINED COMPRESSIVE STRENGTH OF SOIL

As by the addition of polypropylene fibers in different percentages to the soil the unconfined compressive strength of soil is to be determined as per the IS: 2720-Part X-1991. The tests were carried out on the soil samples containing 0%, 0.5%, 1%, 1.5% ,etc. of polypropylene fibers having a length of 24 mm.

- 0.5 % polypropylene fibers

As by adding 0.5 % fibers to the soil, the unconfined compressive strength test (UCC) is conducted as per IS 272- Part X-1991. Then the results were plotted graphically as by taking axial strain as X-axis and axial stress as Y-axis.

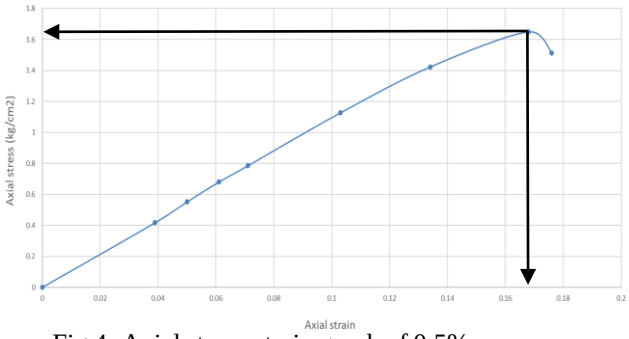


Fig 4- Axial stress-strain graph of 0.5% polypropylene
fibers on soil

From the graph, the axial stress will be increases up to a limit and then decreases. This curve reveals that the maximum compressive strength is obtained as 1.65 kg/cm2.

- 1% polypropylene fibers

As by adding 1% fibers to the soil, the unconfined compressive strength test (UCC) is conducted as per IS: 2720-Part X-1991. Then the results were plotted graphically as by taking axial strain as X-axis and axial stress as Y-axis.

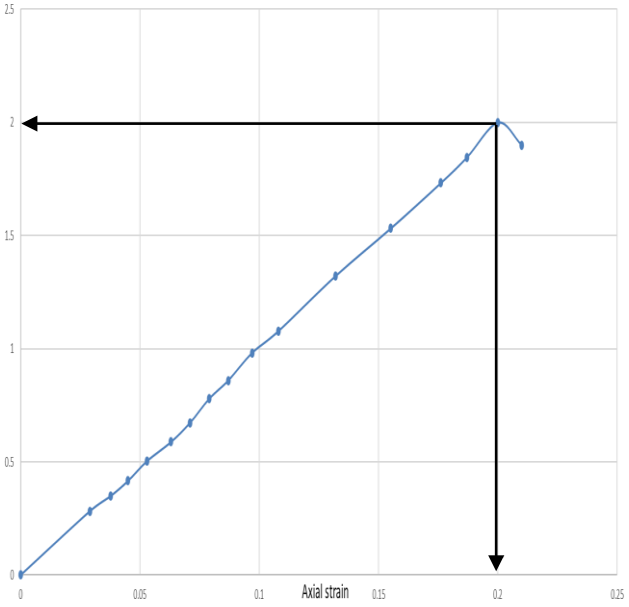


Fig 5- Axial stress-strain graph of 1% polypropylene fibers onsoil

From the graph, the axial stress will be increases up to a limit and then decreases. This curve reveals that the maximum compressive strength is obtained as 2 kg/cm2.

- 1.5% polypropylene fibers

As by adding 1.5% fibers to the soil, the unconfined compressive strength test (UCC) is conducted as per IS: 2720- Part X-1991. Then the results were plotted graphically as by taking axial strain as X-axis and axial stress as Y-axis.

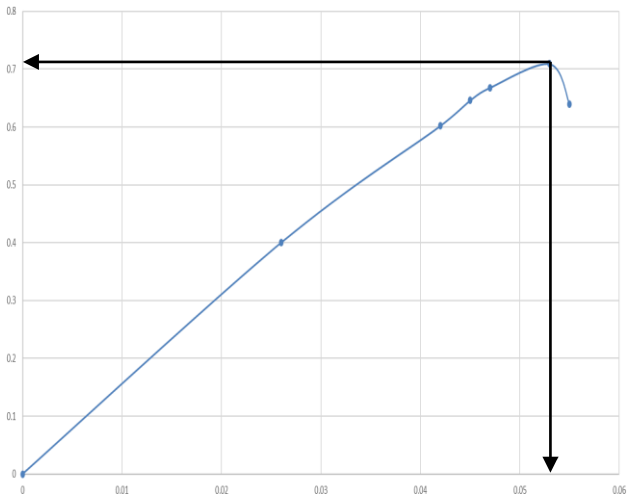

Fig 6- Axial stress-strain graph of 1.5% polypropylene fibers on soil

From the graph, the axial stress will be increases up to a limit and then decreases. This curve reveals that the maximum compressive strength is obtained as 0.71 kg/cm2.

And also the compressive strength will be increased up to a limit and then decreases in the UCC test.

## VII VARIATION IN BEARING CAPACITY OF SOIL

Bearing capacity of soil was estimated using Terzaghi's equation and the variation in ultimate bearing capacity of soil was determined by varying the percentage of polypropylene fiber. The footing was assumed to be square footing of size 1.5 m embedded at a depth of 1 m. The results are shown in table.

Table 2- Variation in bearing capacity of soil

| PERCENTAGE FIBER (%) | BEARING CAPACITY ($kN/m^2$) |
|---|---|
| 0 | 145 |
| 0.5 | 582 |
| 1 | 702 |
| 1.5 | 260 |

The bearing capacity of soil increased with increase in polypropylene fiber up to 1 %. With further addition of fiber the bearing capacity decreased.

## CONCLUSIONS

The primary purpose of reinforcing a soil mass is to improve its stability by increasing its bearing capacity, and by reducing settlement and lateral deformation. The value of unconfined compressive strength and bearing capacity of soil increased considerably on adding polypropylene fiber.

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