STABILIZATION OF CLAYEY SOIL USING POLYPROPYLENE FIBER

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Abstract - *In India, a major portion of total land area is covered by clayey soil. Of this, a large proportion is expansive soil. Structures constructed over this expansive soil may be severely damaged due to its high swell-shrinkage behavior. So such soils need to be stabilized to increase its strength, durability and to prevent erosion. Various studies have been carried out on expansive soils to improve its properties. Soil stabilization is one of the promising techniques used to improve the geotechnical properties of soil and has become the major practice in construction engineering. This project aims to conduct a study to check the improvements in properties of clayey soil by adding polypropylene fiber. By varying percentage of reinforcement (0%, 0.5%, 1% and 1.5%), the soil parameters such as UCS and DRY DENSITY may be studied. These values are compared to that of a control specimen.*

Key Words: **Swell, Liquid Limit, UCC, Compaction, Polypropylene fiber and clayey soil.**

1. INTRODUCTION

Soil stabilization is an effective and reliable technique for altering important soil properties. Several reinforcement methods are available for stabilizing expansive soils such as stabilization with chemical additives, rewetting, soil replacement, compaction control, moisture control, surcharge loading and thermal methods [1]. These techniques have wide application in areas like construction of road, slope stabilization, railway embankments, and so on [8]. Soils are generally stabilized to increase their strength and durability or to prevent erosion and dust formation in soils. The main aim is the creation of a soil material for the designed life of the engineering project. The properties of soil vary a great deal at different places. Various methods are employed to stabilize soil and the method should be verified in the lab with the soil material before applying it in the field.

1.1 Needs And Advantages

- It improves the strength of the soil, thus, increasing the soil bearing capacity.
- It is more economical both in terms of cost and energy to increase the bearing capacity of the soil rather than going for deep foundation or raft foundation.
- It is also used to provide more stability to the soil in slopes or other such places.
- Sometimes soil stabilization is also used to prevent soil erosion or formation of dust, which is very useful especially in dry and arid weather.
- It helps in reducing the soil volume change due to change in temperature or moisture content.
- Stabilization improves the workability and the durability of the soil.

1.2 Materials Used

1.2.1 Soil:
Soil used for the study is clayey soil. It has been collected from Ahalia campus, Kerala. It is a soil of high plasticity. The high plasticity index indicates high swell potential, the most problematic soil type under light structures.

1.2.2 Reinforcement:
Polypropylene fibre is used in this study and it is a synthetic material. Fibers used for this study has a length of 12mm were purchased from the market. Polypropylene fibers are hydrophobic, non-corrosive and resistant to alkalis, chemicals and chlorides.

Table -1: Properties of polypropylene fiber

Fiber Properties	Values
Specific Gravity	0.91
Density (gm/cc)	0.90
Average Length (mm)	12
Average Diameter (mm)	0.048

2. PREPARATION OF SAMPLE

The soil sample should be oven dried at approximately 105°C and then ground. Content of fiber to be added in the soil is herein decided by equation 1. The different values adopted

for the percentage of fiber reinforcement are0%, 0.5%, 1% and 1.5%. 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.

$$\rho f = \frac{V_f}{V}$$

Where,

ρf = ratio of fibre content,
V_f = weight of the fibre,
V = weight of the air-dried soil

2.1 Properties Of Clayey Soil

Table - 2: Properties of clayey soil

Sl NO.	PROPERTY	VALUE
1	USCS Classification	CH
2	Specific Gravity(G)	2.87
3	Density(ρ)	1.575
4	Liquid Limit(W_L)	62.50%
5	Plastic Limit(W_P)	30%
6	Plasticity Index(I_P)	15.84%
7	Maximum Dry Density	1.29gm/cc
8	Optimum Moisture Content	21.55%
9	Free Swell Index(F.S.I)	85%
10	Unconfined Compressive Strength(q_u)	2.486kN/m²

2.2 Behaviour Of Soil Modified With Polypropylene Fiber

2.2.1 Variation of swell characteristics with the addition of PP fiber

Free swell or differential free swell, also termed as free swell index, is the increase in volume of soil without any external constraint when subjected to submergence in water.

The Free Swell Index test has been conducted on soil sample with the addition of 0%, 0.5%, 1% and 1.5% of fibre content. From the graph (chart - 1), it is seen that, the free swell index value of soil sample decreases with the addition of fibre content. But with the addition of 1% fiber content, the free swell index value becomes zero and remains the same. This may be due to resistance to swelling developed by the addition of fibre.

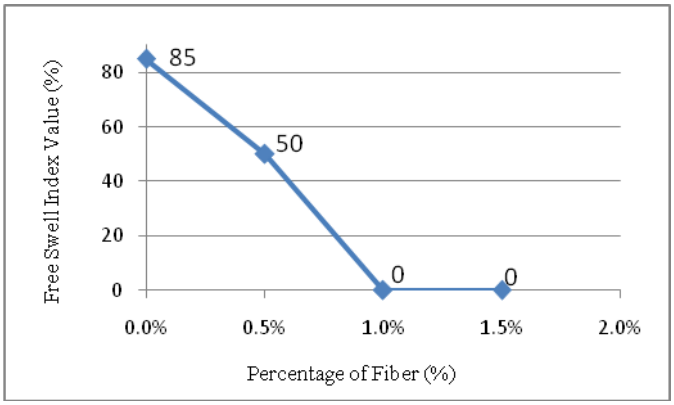

Chart - 1: Variation of free swell index values with fiber content

2.2.2 Variation of liquid limit with the addition of PP fiber

It can be defined as the minimum water content at which the soil, though in liquid state, shows small shearing strength against flowing. It is usually measured by the Casagrande's apparatus and is denoted by W_L.

The Liquid Limit test has been conducted on soil sample with the addition of 0%, 0.5%, 1% and 1.5% of fibre content. From the graph (chart-2), it is seen that the liquid limit values increases with the addition of various percentages of fiber content.

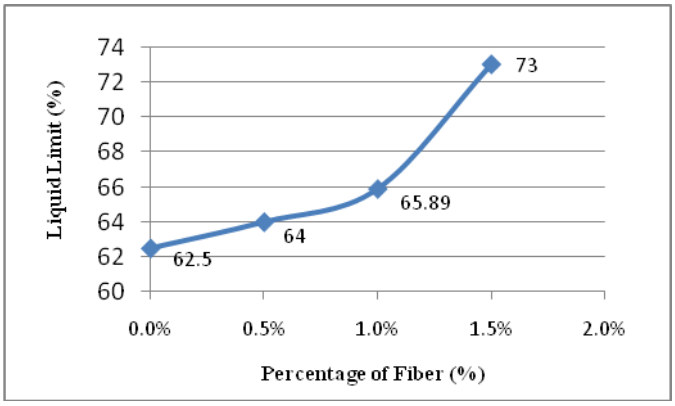

Chart - 2: Variation of liquid limit with fiber content

The observed changes are attributed to the replacement of soil grains by fibers. The soil reinforced is more continuity than the soil non-reinforced; consequently, the liquid limit of soil reinforced increases. This result contrasts with the result' Babak Amini Behbahani [7], in regard to behavior of soil.

2.2.3 Variation of compaction characteristics with the addition of PP fiber

The Standard Proctor Compaction test has been conducted on soil sample with the addition of 0%, 0.5%, 1% and 1.5% of fibre content. From the graph (chart - 3), it is seen that the specific gravity value increases up to 1% of fiber content and decreases with the addition of 1.5% fiber content.

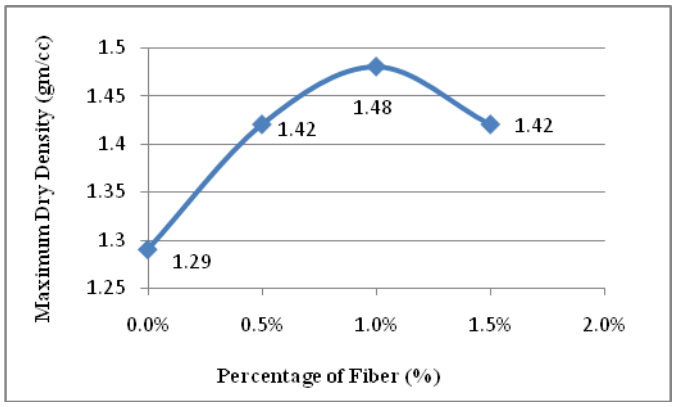

Chart - 3: Variation of MDD values with fiber content

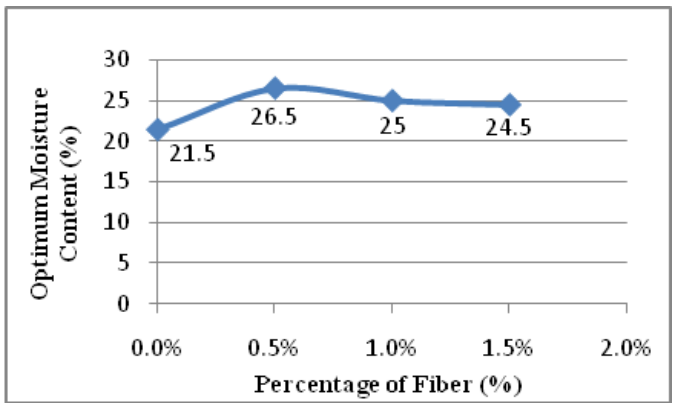

Chart - 4: Variation of OMC values with fiber content

When PP fiber is added to the soil in the presence of water, it fills the voids of soil thus contributing to the dry density. When higher content of PP fiber is added, the amount of water absorbed by the stabilizer in the mixing stage may get expelled under the compactive effort thus contributing to the increasing OMC at higher stabilizer content and reduce after the addition of 1% of stabilizer. From the graph, it is observed that the MDD value at 1% fiber content is 1.48gm/cc.

2.2.4 Variation of Compressive Strength with the addition of PP fibre

Unconfined Compressive Strength test were carried out to find the variation in the strength characteristics of a soil stabilized with PP fiber.

The UCC test has been conducted on soil sample with the addition of 0%, 0.5%, 1% and 1.5% of fiber content. From the graph (chart - 5), it is seen that the UCS value increases up to 1% of fibre content and decreases with the addition of 1.5% fiber.

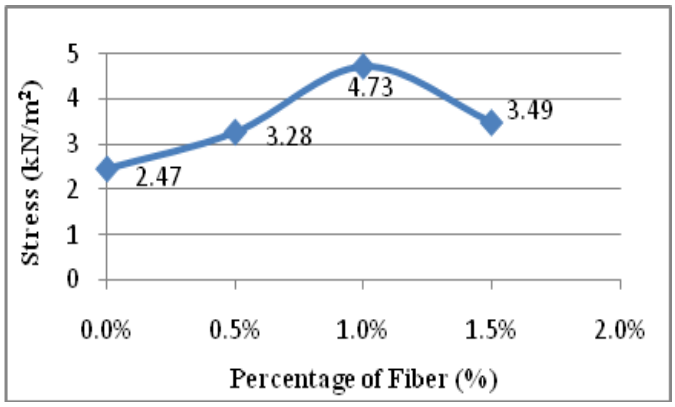

Chart - 5: Variation of UCS values with fiber content

When the PP fiber content is increased beyond the optimum percentage there is a decrease in the compressive strength value. This decrease may be caused by the action of PP as a cushion in the soil and not providing enough water molecules to hold the soil particles together, since the additional water molecules will stick on the surface of the stabilizers. The maximum value of UCC was obtained as 4.73 kN/m² at 1% PP fiber.

3. STRENGTH IMPROVEMENT RATIO

The strength improvement ratio has been calculated from UCC value. The values are given in table - 3.

Table – 3: SIR values

SL. NO.	Percentage of Fiber (%)	SIR Value
1.	0%	1.00
2.	1%	1.023
3.	1.5%	1.160

It is seen that, the S.I.R value increases with increase in the percentage of fiber content.

4. CONCLUSION

This study investigated the effect of adding polypropylene fiber and strength behaviour of clayey soil. The effect of fiber reinforcement on clayey soil was studied by using the results obtained from a series of swell, liquid limit, compaction and unconfined compression test. Based on the result presented in this paper the following conclusions are drawn.

- With increase in the fiber content, the free swell index value of reinforced soil decreases to zero at 1% of fiber.
- Due to increase in the fiber content, the liquid limit of reinforced soil increases due to the replacement of soil grains by fiber.
- The maximum dry density of the soil increases with the addition of fiber content up to 1% of fiber and then decreases with the addition of 1.5% fiber. This is due to the fact that the dry unit weight of fiber is more than that of the soil.
- In view of increase in the fiber content, the UCC values of reinforced soil increases up to 1% fiber and decreases with the addition of 1.5 % fiber.
- From this investigation, it is clearly indicated that the free swell index value of the reinforced soil decreased drastically which means that the soil is not subjected to any volumetric changes with the addition of fiber.
- Hence addition of 1% of stabilizer was taken as the optimum percentage of PP fiber for stabilizing the soil.
- Also the strength of the clayey soil was improved due to fiber addition and can be concluded that PP fiber can be used effectively for the stabilization of clayey soil.

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