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Stabilization of Black Cotton Soil using Polypropylene Fibre

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Abstract—*Civil engineering includes the conception, analysis, design, construction, operation and maintenance of a diversity of structures facilities and system. All of them are built on soil or rock. The ultimate support for any structure is provided by the underlying soil material and therefore, the stability of structure depends on it. In India, a large portion of total land area is covered by black cotton soil. Structures constructed over this expansive soil may be severely damaged due to its high swell-shrinkage behaviour. These soils are highly compressible and have very low bearing capacity. It is extremely difficult to work with such soils. So such soils need to be stabilized to increase its strength, durability and to prevent erosion. Soil stabilization is one of the promising techniques used to improve the geotechnical properties of soil. This project aims to conduct a study to check the improvements in properties of black cotton soil by adding polypropylene fibre. By varying percentage of reinforcement (0%, 0.5%, 1%, 1.5%, 2%, 2.5%, 3%), the results show the effect of polypropylene fibre on geotechnical properties of black cotton soil(expansive soil).*

Keywords*: Polypropylene fibre Black cotton soil, compressive strength, Stabilization, Expansive soil.*

1. INTRODUCTION

Black cotton soil also known as expansive soil, mainly found in central India and Deccan plateau such as Maharashtra, Madhya Pradesh, Andhra Pradesh, Karnataka etc. The black cotton soil exhibits low bearing capacity, low permeability and high volume change. This soil have a tendency to swell and shrink with the variation in moisture content. Such tendency is due to the presence of fine clay particles, Swell, when they come in contact with water, resulting in alternate swelling and shrinkage of soil due to which differential settlement of structure takes place. As a result of which significant distress in the soil occurs, causing severe damage to the overlying structure. Therefore prior to the construction of a road and any other engineering structures on such subgrade, It is important either replace it with non-expansive soil or make it suitable for construction. Replacement of expansive soil with a non-expansive soil material is a common method of reducing shrink-swell risk. In this case when expansive soil or stratum is thin, then the entire layer can be removed. However, often the soil or stratum extends too deep and in that case this method is not economically efficient, therefore the best possible option is to stabilize the existing soil with suitable stabilizers. In this paper present a study, carried out on soil stabilization using polypropylene fibre for improving the property of expansive soil. Various tests like CBR, MDD were performed on the soil samples prepared by using polypropylene fibre mixed with black cotton soil at different percentages. On the basis of the results obtained from these tests, it may be concluded that geotechnical properties of black cotton soil can be significantly improved by mixing it with polypropylene fibre as stabilized material.

2. LITERATURE REVIEW

Soil stabilization is a procedure where we enhance engineering properties of soil with the utilization of natural or blended admixtures. In the past numerous analysts have completed their examination work for enhancing the quality of dark cotton soil utilizing diverse sorts of admixture at various rates. The present paper manages the adjustment of dark cotton soil utilizing polypropylene fibre. A detailed literatures have been reviewed on this topic i.e. related to black cotton stabilization and some of the reviewed literatures are presented in proceeding paragraphs.

Ranjan et al (1996) have studied on various types of soils like sand, medium sand, fine sand, silty sand and silt reinforced with polypropylene monofilament coir and bhabar the result of triaxial test showed greater ductility, no loss of post peak strength and increase in stiffness. Due to tensile strength in fibres confining pressure is greater than critical confining pressure.

Kumar, Walia and Bajaj (2007) have reinforced the black cotton soil with polyester synthetic. They investigated on unconfined compressive fly ash, lime and randomly oriented fibres on the Geotechnical characteristics of expansive soils. The results shows that unconfined compressive strength increases with increase of fibre content.

Sanjeev Tanaji and Sushma have stabilized the black cotton soil using industrial waste. In the results they concluded that

value of CBR and MDD increases by adding the industrial waste to black cotton soil. Udaya Shankar and S.C. Puranik have stabilized the black cotton soil using fly ash. In the results they concluded that value of OMC and CBR increases with addition of fly ash.

3. OBJECTIVES

i. To evaluate the index properties of black cotton soil.

ii. To increase the strength characteristic of black cotton soil using polypropylene fibre.

iii. To compare the strength properties of black cotton soil with fibre and without fibre.

iv. To identify the increasing in strength of soil by replacing fibre at various percentages.

v. To increase the soil bearing capacity by adding polypropylene in various percentages.

4. MATERIALS AND METHODOLOGY

4.1 Materials:

4.1.1 Black cotton soil: Black cotton soil (BC soil) is a very clayey soil. They are of variable thickness, underlain by dark sticky material known as "Black soil". Black cotton soil when interacts with water it either swells or contracts and bringing about minutes to the structure which are by and large not identified with coordinate impact of stacking. Because of its high volumetric changes it isn't appropriate for construction. It swells and shrinks too much because of present of fine clay particles. Thus black cotton soil must be dealt with by using suitable admixtures to stabilize it.

Figure 1: Black cotton soil

4.1.2 Polypropylene fibre: Polypropylene fibre has been collected from Chawri bazar new delhi. Fibers are used to assess a procedure for avoiding split improvements in muds because of drying up by the utilization of short polymeric fibers. The incorporation of haphazardly disseminated, discrete malleable support components in compacted dirt offers a potential answer for the issue of sloughing shakiness of levees.

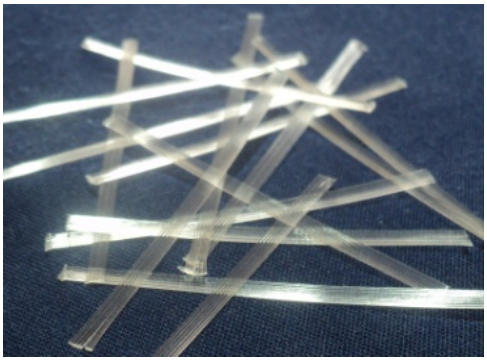

Figure 2: Polypropylene fibre

Table 1 Properties of polypropylene fibre

S. no	Fiber properties	Value
1.	Specific Gravity	0.91
2.	Density(gm/cc)	0.90
3.	Average length(mm)	12
1.	Average diameter(mm)	0.045

4.2 Methodology

Following laboratory tests have been carried out:

These tests were carried out on both natural soil and stabilized soil with polypropylene fibre.

1. Specific Gravity
2. Atterberg limits
   i. Liquid limit
   ii. Plastic limit
3. Grain sieve analysis
4. Proctor compaction
5. Unconfined compression test (UCS).
6. California bearing ratio test (CBR)
7. Direct shear test (DST)

4.3 Steps involved in experiments:

4.3.1 Specific gravity of the black cotton soil: The specific gravity of black cotton soil is proportion between the weight of the solids and weight of equivalent volume of water. It is measured with the help of a volumetric flask in a simple basic test setup where the volume of the black cotton soil is discovered and its weight is divided by the weight of equivalent volume of water. The specific gravity is denoted by "G".

4.3.2 Liquid limit by Casagrande's apparatus: It is the water content of the black cotton soil between liquid state and plastic state of the black cotton soil. It can be defined as the minimum water content at which the black cotton soil, however in liquid state, indicates little shearing against the flowing. The Casagrande's apparatus cuts up a groove of size 2mm wide at the base and 11mm wide at the top and 8mm high. It is denoted by 'WL'.

4.3.3 Plastic limit: The plastic limit lies between the plastic and semi-solid state of the black cotton soil. It is determined by rolling up out a thread of the black cotton soil on a level surface which is non-permeable. It is the minimum water content at which the black cotton soil will start to crumble while rolling it into a string of 3mm diameter. Plastic limit is denoted by 'Wp' .

4.3.4 Particle size distribution by sieve analysis: The distribution of particles of various sizes determines many various physical properties, for example, its strength, permeability, density and so on. Particle size distribution is done mainly for the coarse grained soil. It is followed by plotting the outcomes on a semi log graph.

4.3.5 Proctor compaction test: The compaction procedure helps in expanding the bulk density by driving out the air from the voids. The dry density mainly depends on the moisture content in the black cotton soil. The maximum dry density (MDD) is achieved when the black cotton soil is compacted at high moisture content and almost all the air is driven out, this moisture content is known as optimum moisture content

5. RESULT AND DISCUSSION

The index properties of black cotton soil tests results are summarized in Table-2.

Table 2: Characteristics of Black cotton soil

S. no	Property	Value
1.	Specific gravity(G)	2.71
2.	Liquid limit	70%
3.	Plastic limit	35%
4.	MDD	1.7 g/cc
5.	OMC	23%

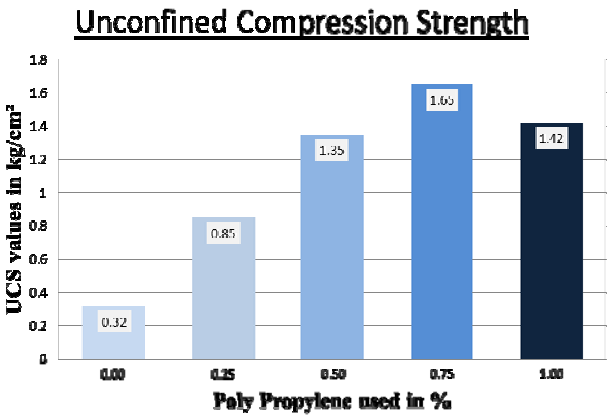

Figure 3: Unconfined Compression strength

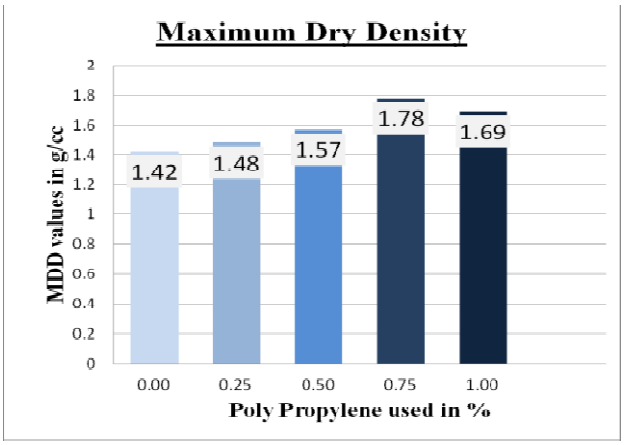

Figure 4: Maximum Dry Density

6. 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 series of liquid limit, compaction and unconfined compression test. Based on the result presented in this paper the following conclusions are drawn.

1. Specific gravity of black cotton soil decreased with the addition of polypropylene fibre .
2. with the increase in the fiber content, the liquid limit of reinforced soil increases due to the replacement of soil grains by fiber.
3. The maximum dry density of the soil increases with the addition of fiber content up to 0.75% of fiber and then decreases with the addition of 1% fiber. This is due to the fact that the dry unit weight of fiber is more than that of the soil.
4. With the increase in the fiber content, the Unconfined compression strength values of reinforced soil increases up to 0.75% fiber and decreases with the addition of 1 % fiber.
5. Hence addition of 0.75% of stabilizer was taken as the optimum percentage of Polypropylene fiber for stabilizing the soil.
6. Also the strength of the clayey soil was improved due to fiber addition and can be concluded that polypropylene fibre fiber can be used effectively for the stabilization of clayey soil.

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