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Expansive Soil Stabilization using Plastic Fiber Waste Polypropylene

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Abstract: Expansive soils are often found in most of the parts of India. Black cotton soil is one of the types of expansive soil. Soil is the basic foundation for any civil engineering structures. Expansive soils are known as swelling soils, which posses the tendency of swelling and shrinkage with the variation in moisture content. These soils are not good for construction as this soil causes severe damage to the structure. To avoid these failures in engineering field soil must be stabilized to achieve soil properties. Change in soil properties by chemical and physical means in order to enhance the engineering properties of the soil is known as soil stabilization. The Soil is improved using many methods and materials in geotechnical engineering. Production of non- biodegradable waste like plastic is going on increasing in recent times. In this thesis, black cotton soil is stabilized using waste materials like plastic waste fiber- polypropylene. Polypropylene fiber content is available at low cost. Polypropylene which is one of the types of the plastic waste is used as soil stabilizer. As it takes extremely long time for natural decomposition, plastic fiber waste is mixed with expansive soil which helps in mitigating the volume change behavior. This study provides the laboratory investigations on Strength parameters of expansive soil and reinforced soil. Tests such as Atterberg's limit, Compaction Test, Swell Index, CBR, and UCS Test are carried out. These tests were conducted on different proportions of reinforced soil until optimized proportion is arrived. Laboratory investigations are carried on black cotton soil blended with small proportions of polypropylene fiber content of 0.5%, 1.0%, 1.5%, and 2.0% by weight of dry soil. Test results were analyzed and investigated to know the effectiveness of plastic fiber waste on Strength characteristics of expansive soils.

Keywords: Expansive soil, Soil stabilization, polypropylene, Atterberg's limit, CBR.

I. Introduction

In many areas of Telangana the main problem in construction is the poor bearing capacity of the soil. Most of these areas are covered with clay of very soft consistency. Expansive soils are known as swelling soils, which posses the tendency of swelling and shrinkage with the variation in moisture content. These soils are not good for construction as this soil causes severe damage to the structure. To avoid these failures in engineering field soil must be stabilized to achieve soil properties. Stabilization is mostly used in variety of engineering works, where it is main objective is to increase the strength and improve the durability and stability of the soil in a cost effective way. Soil stabilization is the application or treatment of soil by mechanical methods or addition of modifier (cement, lime, bitumen etc.,) or combination of both to improve the strength of the soil. Stabilization improves the workability and the durability of the soil. Expansive soil can also be stabilized by using waste materials.

Polypropylene which is one of the types of the plastic waste is used as soil stabilizer. As it takes extremely long time for natural decomposition, plastic fiber waste is mixed with expansive soil which helps in mitigating the volume change behavior. In 2013, Polypropylene production was about 55 million tones. Based on production, synthetic plastic is the world's second most widely produced Plastic. Polypropylene is similar to polyethylene in many aspects.

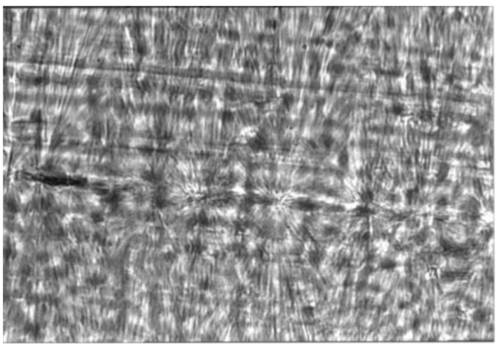


Fig1: Micrograph of polypropylene fiber

II. Methodology

1. **Soil:** The black cotton soil taken for this study is obtained from Patelguda village, Sangareddy District, Telangana. About 50 kg of sample is collected at a depth of 2.5 m and brought to the soil mechanics laboratory in our college for the project work. Standard test on the soil is carried out in our laboratory with the collected soil sample and properties of the soil are determined.

TABLE 1: properties for the black cotton soils

Properties of black cotton soil	value
Consistence limit (%) Liquid limit Plastic limit Plasticity Index	 59 29 30
IS classification	CH
Maximum dry density (g/cc)	1.68
Optimum moisture content (%)	19
California Bearing Ratio (%)	1.94
Unconfined Compressive Strength (kg/cm²)	1.15

2. **Polypropylene Plastic Fiber (PPF):** It is a mixture of plastic fiber collected from used chairs and bottles. Fiber strips which passes through 10mm sieve is used in this investigation.

Fig 2: GGBS chemical properties

Table 2: Mechanical properties of polypropylene Fiber

Behaviour Parameters	values
Fiber Type	Single
Unit weight	0.91 g/cm3
Average Size	10mm
Tensile strength	350MPa
Modulus of elasticity	1800 N/mm2
Density	0.92 g/cm3
Burning point	590˚ c
Fusion point	165
Resistance to acidic and alkali actions	Very good

III. Results And Disscussion

Basic properties of Black Cotton Soil are determined by conducting laboratory tests as per IS code specifications, results are tabulated. Further, soil stabilized with polypropylene fiber and the strength parameters like MMD, CBR and UCS are determined by conducting compaction, CBR (California bearing ratio) and UCS (Unconfined compressive strength) tests respectively.

Following are the composition of the soil samples used in this investigation. By using these compositions further experiments are done and results are tabulated.

Table 3: Composition of soil

Soil sample	**Composition**
Sample 1	BC
Sample 2	BC + 0.5% PPF
Sample 3	BC + 1% PPF
Sample 4	BC + 1.5% PPF
Sample 5	BC + 2% PPF

Table 4: Test results of soil sample 1

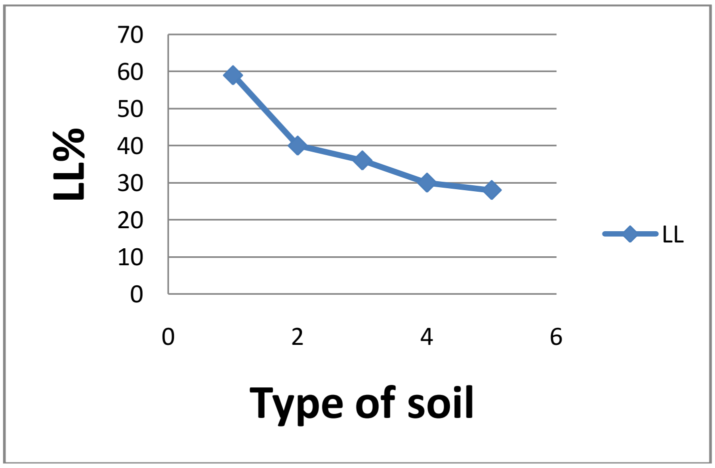
Liquid limit	59
Shrinkage limit	14.5
Plastic limit	29
Plasticity index	30
Free swell index	58
Optimum moisture content	19
Dry density	1.68 g/m
UCS	1.15
CBR	1.94
Soil classification	CH
Grain % finer	90.76

Fig 3: photographs while working with the project

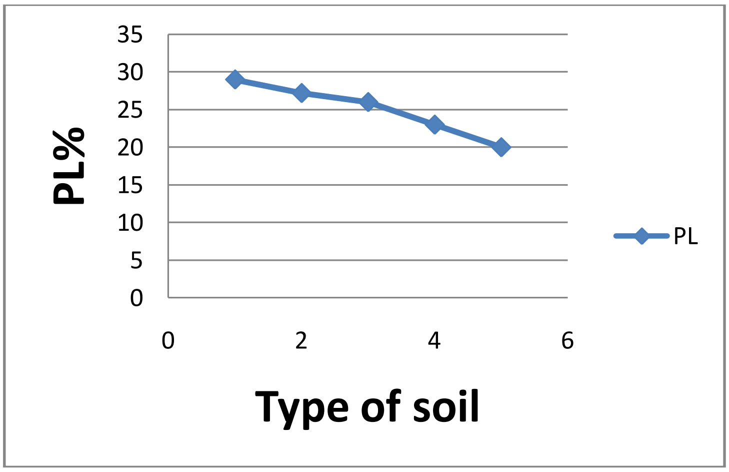
1. **Atterberg's limit:** The soil characterization tests were performed on each soil sample in accordance with IS 2720: part 5. The values of Atterberg's limits liquid limit, plastic limit and plasticity Index are as shown in table and graph 1. The result shows fairly significant decrease in plasticity Index (PI) indicating an improvement in soil.

Table 5: Test results

Type of soil	LL %	PL %	PI %
Sample 1	59	29	30
Sample 2	40	27.2	12
Sample 3	36	26	9
Sample 4	30	23	7
Sample 5	28	20	5

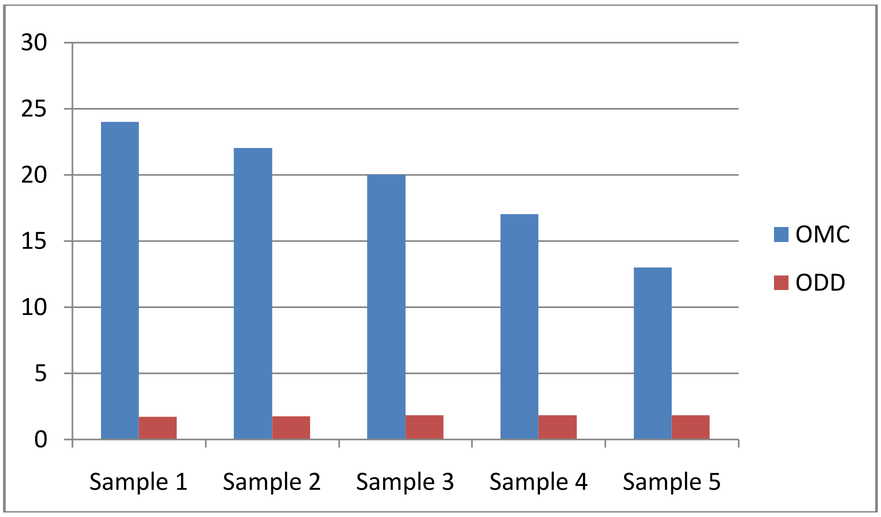


Graph 1 (a) variation of Liquid limit with PPF



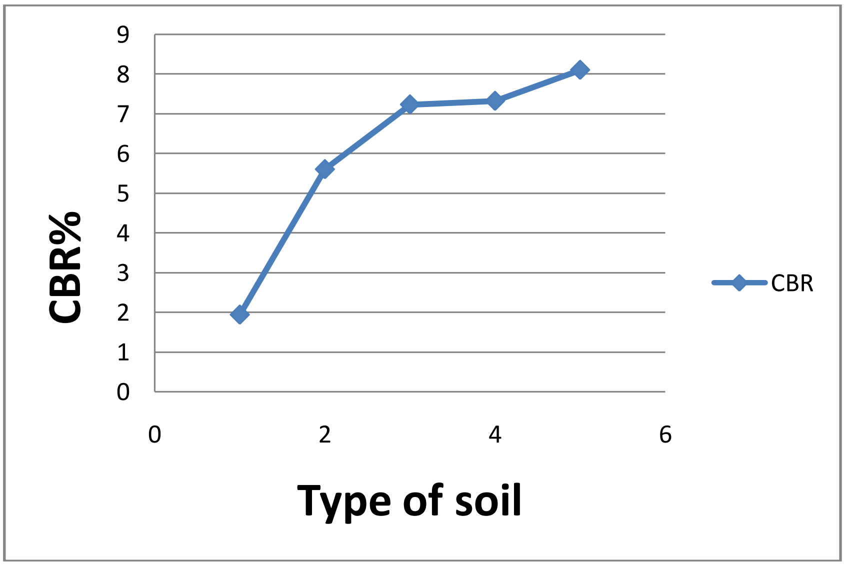
Graph 1(b) variation of plastic limit with PPF

2. **Compaction:** the test was carried out in accordance with IS 2720: part.8. The results are summarized in table and graph 2. It can be seen that there is significant changes in the MDD and OMC due to the addition of PPF to the native soil.



Graph 2: variation of MMD and OMC with PPF

3. **California bearing ratio (CBR):** CBR tests were conducted in accordance with IS 2720:Part16 for native soil and soil with PPF with various proportions. Results are summarized in table and graph 3.

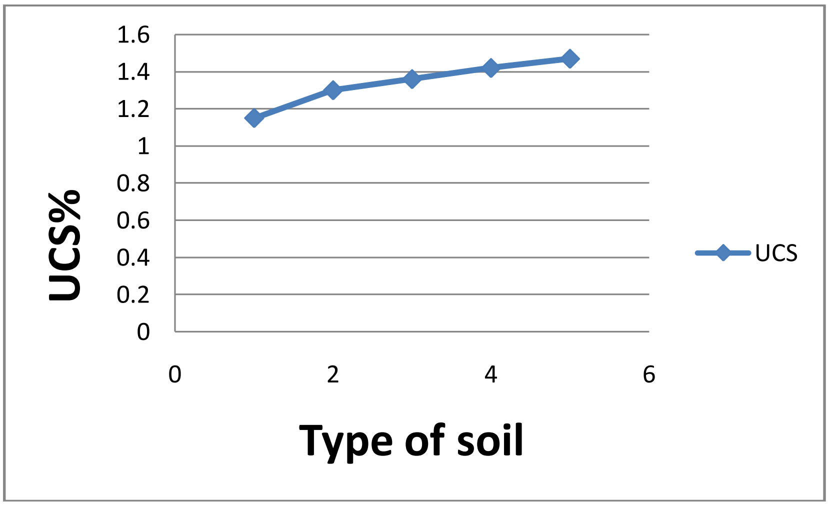


Graph 3 variations in CBR curve

4. **Unconfined compressive strength (UCS):** the black cotton soils blend with PPF. The PPF gave increased value of compressive stress. The results are summarized in table and graph 4.

Table 6: Test results of UCS

Type of soil	UCS (%)
Sample 1	1.15
Sample 2	1.3
Sample 3	1.36
Sample 4	1.42
Sample 5	1.47



Graph 4 Variation of UCS curve

Table 7: Soil treated with PPF, Engineering properties of black cotton soil

Particulars	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Liquid limit (LL) (%)	59	40	36	30	28
Plastic limit (PL) (%)	29	27.2	26	23	20
Plasticity index (PI) (%)	30	12	9	7	5
Optimum moisture content (OMC) (%)	24	22	20	17	13
Maximum dry density (MMD) (kg/cc)	1.68	1.75	1.815	1.83	1.8
California bearing ratio (CBR) (%)	1.94	5.6	7.23	7.32	8.1
Unconfined compressive strength (UCS) (kg/cm²)	1.15	1.3	1.36	1.42	1.47

IV. Conclusions

This study suggests that if plastic fiber content is properly mixed, it can be used as a great soil stabilization technique. A series of tests were conducted to study the effects of polypropylene fiber. The following are the conclusions which are drawn from the test result.

1. With the increase of PPF content Liquid limits, plastic limit and plasticity index decrease, which makes the soil less plastic and hence plasticity index reduces.
2. With the increase of PPF content optimum moisture content goes on decreasing while maximum dry density goes on increasing, hence compactability of soil increases and making the soil more dense and hard at soil sample 4.
3. With the increase in PPF content Unconfined compressive strength, CBR (unsoaked) values increase, suggest its suitability as good stabilizer to improve performance of soft soils.
4. With the increase of PPF content compressive strength increases as well as CBR value also increases in percentage of PPF which is achieved by soil sample 5.

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