

**STABILIZATION OF EXPANSIVE SOIL WITH POLYPROPYLENE FIBRE
ALONG WITH LIME**B SURESH¹, N VENKAT RAO², K ARUN KUMAR³ D M V PRANEETH⁴¹Department of Civil Engineering, Institute of Aeronautical Engineering²Department of Civil Engineering, Institute of Aeronautical Engineering³Department of Civil Engineering, Bharat Institute of Engineering and Technology⁴Department of Civil Engineering, Institute of Aeronautical Engineering

Abstract —The main focus of this paper is to investigate the geotechnical properties of the black cotton expansive soil reinforced with polypropylene fibre along with lime at different proportions. In the present study three different percentage of polypropylene fibre (0.5%, 0.75%, and 1%) by weight of parent soil and three different percentage of lime (0%, 2%, 5%, and 8%) by weight of parent soil were studied. It is identified that due to the addition of polypropylene fibre CBR strength has been increased up to desired strength level by adding the various % of lime and fibre. significant improvement in the mechanical behavior of the soil –lime-fibre mixtures indicate that there is some potential for the use of lime on fibre mixed with expansive soil in engineering practice.

Keywords- polypropylene fibre, expansive soil, CBR strength, geotechnical properties and soil reinforcement

I. INTRODUCTION

The problem of expansive soils is widespread throughout world. Some of the countries like Australia, Canada, USA, China Egypt and India are facing this problem the clay mineral that belongs to Montmorillonite group is chiefly responsible for expansiveness. Expansive soils are also called swelling soils or clayey soils the problem associated with these soils is when they are saturated their volume increased when they are dried they shrink this alternative shrinking and swelling is responsible for development of cracks on surface. Black cotton soils found in many parts of India belong to this category

II. LITERATURE REVIEW

Andersland and khattak (1979) made a study on the kaolinite soil with the following properties $\Phi = 20^\circ$, LL =47.8%, PL= 20.3% ,G =2.7, cellulose fibre ($f_1 = 1.6\text{mm}$, dia =0.02mm, fibre content 16 – 40%) the triaxial test was conducted the test results indicates the addition of fibre at 16% increase the peak shear strength by 43% when the pure kaolinite is used.

Gray and Ohashi (1983) made an extensive study on the shear strength of the soil reinforced with fibres and they concluded the inclusion of fibres in sands increases peak shear strength and limited post peak decrease in shear resistance.

Gray and Al-Refeai (1986) studied on Muskegon pure sand $D_{50} = 0.41\text{mm}$, $c_u = 1.5$, $\Phi = 39^\circ$ and 32° reinforced with three types of fibres for this work triaxial test were conducted. The test results shows the strain is very low and the strength increases with the increase of 2% fibre content by weight.

Setty and Rao (1987) have investigated on lateritic soil G=16%, S=60%, M=21%, C=1% and $\Phi = 39^\circ$ at optimum moisture content of 16%, LL=33%, PI=7.3%, and reinforcement with polypropylene fibre with dia 0.5mm and fibre content of 0,1,2,3,4,5. The triaxial test, CBR and tensile test are conducted the results indicated that the addition of fibres increases cohesion and slightly decreases Φ and also showed that CBR value has been improved by 2.2 times up to 2% fibre content and also improves dry strength.

Maher and Gray (1990) have conducted triaxial test on the sample with the addition of fibres and they identified that low modulus fibres (rubber) contribute little to strength despite higher interface friction and the failure surface is plain and oriented at $(45 + \Phi/2)$

Bauer and fatani (1991) have investigated on silt sand reinforcement with steel fibre and copper fibre they conducted direct shear test, and modified proctor density test and concluded that the residual strength of the composite is 200% to 300% higher than unreinforced soil.

Michalowski and Zaho (1996) have reinforced the dry sand with polyamide monofilament and steel fibres and they concluded that the addition of steel fibres increases the peak stress by 20% and the presence of fibres inhibited the sample dilation and made sample stiff.

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.

Charan (1996) studied on silt, sand to coarse sand reinforced with polypropylene and natural fibre coir and bhabar the triaxial and CBR test were conducted the test results shows that the confining pressure is less than critical confining pressure and the CBR value is improved by two times at the fibre of 1.5%.

Santoni et al (2001) studied on six types of non-plastic cohesion less soils reinforced with monofilament polypropylene fibre the unconfined compressive strength of reinforced soil on the moisture content 2.6% and saturation 14% and they found optimum fibre content is 0.8% and fibre content is less than 0.6% caused strain softening more than 0.85% causes strain hardening.

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.

Chandra et la (2008) have studied on three types of soil reinforced with polypropylene fibre of 0.3mm diameter the static triaxial test of unreinforced and reinforced soil shows that uniaxial compressive strength is 3.824, 4.836 and 9.712 Mpa respectively

III. MATERIALS USED

The disturbed expansive soil was collected from an open excavation at a depth of 1.5meter below the natural ground level at proposed experimental site in Hyderabad

Basic properties of sample soil	Quantity
Depth of soil	1.5m below the ground surface
Specific gravity	2.70
IS classification	CH-MH
Gravel%	1.0%
Sand%	35.20%
Silt%+clay%	63.80%
Optimum moisture content%	24.93
Maximum dry density%	1.30
CBR%	1.90
Liquid limit%	68
Plastic limit%	48.5
Plasticity index	19.5

Table 1- Basic properties of soil sample

Properties of polypropylene fibre provided by Reliance industries Pvt.Ltd generally it is manufactured by polymerization of propylene produced by purifying of petroleum. It is a common fibre for reinforcement of soil. The manufacturing of this fibre is done in two forms monofilament and fibrillated. Monofilament fibres are individual cylindrical fibres. Fibrillated fibres are flat tape like fibres. Polypropylene fibres are light in weight among all other synthetic fibres.

Properties of polypropylene fibre	specifications
Colour	Natural
Specific gravity	0.91
Denier (as per DIN-53812)	6.30
Tenacity (as per DIN-53816)	4.63
Material	Virgin polypropylene

Length, mm	12
Diameter, microns	18
Tensile strength Mpa	300-400
Elastic modulus	6000-9000
Water absorption	None
Surface characteristics	Lustrous white rough surface
Elongation%	55
Modulus of elasticity N/mm ²	1240-1517
Melting point °c	160-170
Ignition point °c	590
Thermal conductivity	Low
Electrical conductivity	Low
Acid and salt resistance	High

Table-2 Properties of polypropylene fibre

The stabilizing agent used for black cotton soil sample is hydrated lime having Cao content as 60%

IV. EXPERIMENTAL PROCEDURES

The experimental work is initiated to find out the effect of lime and polypropylene fibre on the various geotechnical properties of an expansive soil like specific gravity, grain size distribution, atterberg's limits optimum moisture content (OMC), maximum dry density (MDD) and California bearing ratio (CBR). The study is also extended to evaluate the strength characteristics of the sample taken to check the suitability of the composite material for utilization in sub grade, sub base and embankment. The experiments performed by using the collected sample with the following mix proportions.

1. Soil + 2 %, 5% and 8% of lime
2. Soil + 2 %, 5% and 8% of lime + 0.5%, 0.75% and 1% of polypropylene fibres

The following geotechnical properties of the sample were determined

Specific gravity:

The specific gravity of black cotton soil lime and polypropylene fibre were determined according to IS: 2720 (part-III, section-I) 1980 values are tabulated.

Grain size distribution:

Wet sieve analysis was carried out to determine the grain size distribution of soil sample and dry sieve analysis was carried out for lime because it's non-cohesive property.

Atterberg's limits:

The liquid limit, plastic limit and shrinkage limit tests were conducted with only black cotton soil, black cotton + (2%,5% and 8% of lime) and black cotton + (2 %, 5% and 8% of lime) + (0.5%, 0.75% and 1%) of polypropylene fibres according to IS: 2720 (part 5)-1985.

Optimum moisture content (OMC) and maximum dry density (MDD)

The proctor compaction test was conducted with the following mix proportions only black cotton soil, black cotton + (2%,5% and 8% of lime) and black cotton + (2 %, 5% and 8% of lime) + (0.5%, 0.75% and 1%) of polypropylene fibres. The graphical relationship of the dry density to the moisture content is plotted to establish the compaction curve. The maximum dry density is finally obtained from the peak point of the compaction curve and its corresponding moisture content.

California bearing ratio (CBR)

The California bearing ratio was carried out with the following mix proportions only black cotton soil, black cotton + (2%, 5% and 8% of lime) and black cotton + (2 %, 5% and 8% of lime) + (0.5%, 0.75% and 1%) of polypropylene fibres and results are tabulated

V. RESULT ANALYSIS

Specific gravity:

The specific gravity of black cotton soil lime and polypropylene fibre were determined according to IS: 2720 (part-III, section-I) 1980 values are 2.70 and 0.91.

Grain size distribution

According to IS soil classification system soil lying above A-line are clay of low (WL<35), medium (35<WL<50) and high (50>WL) plasticity

Sieve analysis	Soil
Gravel %	16.25
Sand%	25.25
Silt and clay %	65.25

Table -3 sieve analysis

Atterberg's limits

The results were obtained by variation of lime and fibre content with soil sample

Lime %	Fibre %	LL%	PL%	PI%
0%	0.5	73.77	28.29	47.48
	0.75	71.67	32.03	39.03
	1	70.62	34.98	35.64
2%	0.5	76.63	29.58	47.05
	0.75	76.01	31.64	44.37
	1	75.65	31.98	43.67
5%	0.5	66.67	32.84	33.83
	0.75	66.56	33.23	33.33
	1	65.62	34.85	30.77
8%	0.5	63.21	36.96	26.25
	0.75	30.22	39.56	20.66
	1	59.71	42.32	17.39

Table-4 Atterberg's limit

Optimum moisture content (OMC) and maximum dry density (MDD)

Lime %	Fibre %	OMC %	MDD
Only soil	0.5	27	1.42
	0.75	25.6	1.43
	1	22.86	1.46
Soil + 2%	0.5	27.11	1.41
	0.75	26.62	1.41
	1	26.10	1.42
Soil + 5%	0.5	26.25	1.35
	0.75	24.78	1.36
	1	22.17	1.43
Soil + 8%	0.5	32.31	1.37
	0.75	29.51	1.37
	1	29.11	1.38

Table -5 Optimum moisture content and maximum dry density

California bearing ratio (CBR)

Lime (%)	Fibre (%)	CBR Values (%)	
		0 days curing	7 days curing
0%	0.5	9.56	-
	0.75	11.62	-
	1	14.74	-
2%	0.5	40.8	60.5
	0.75	52.9	69.8
	1	69.5	78.6
5%	0.5	79.3	98.6
	0.75	85.3	108.4
	1	95.9	120.4
8%	0.5	108.4	136.5
	0.75	120.6	145.4
	1	131.9	154.4

Table 6- California bearing ratio

VI. CONCLUSION

It has been identified that the plastic limit of the expansive soil is improved with the addition of various % of lime and fibre.

The OMC and MDD of expansive soil were found out to be 22.86% and 1.46 gm/cc respectively at 1% fibre. We found OMC was maximum with 8% lime and 0.5% lime were 32.1 and 1.37 gm/cc

The CBR strength of the expansive soil has been increased up to 1% fibre and 8% lime increase in CBR value indicates the strength of the subgrade soil is increased.

As polypropylene fibre with rough surface with angular shape offers better interlocking with soil particles and improve the strength of the soil subgrade.

It is identified that the CBR value is considerably increased with the addition of lime and fibre is has also been noticed that fibre content 0.75% was very much effective and further increase oin fibre content did not affect the strength behavior

Based on this investigation the CBR strength of fibre-lime treated soil compacted below and above the optimum water content was greater than the CBR strength of plane soil at the same water content.

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