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STABILIZATION OF EXPANSIVE SOIL USING FIBERS

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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 behavior of the soil and rock at the location of any project has a major influence on the success economy and safety of the work. The ultimate support for any structure is provided by the underlying earth or soil material and therefore, the stability of the structure depends on it. Since soil is usually much weaker than other common materials of construction such as steel and concrete, a greater area or volume of soil is necessarily involved in order to satisfactorily carry a given loading. Soils are classified as red soils, laterites and lateritic soils, black cotton soils, alluvial soils, desert soil, forest and hill soils, peaty and marshy soils. Black cotton soils are mostly clay soils and form deep cracks during dry season. An accumulation of lime is generally noticed at varying depths. They are popularly known as "Black cotton soils" because of their dark brown color and suitability for growing cotton. These are also known as Indian rigors. These soils are deficient in nitrogen, phosphoric acid and organic matter but rich in calcium, potash and magnesium. A large part of central India and a portion of south India is covered with this soil. They contain essentially the clay mineral montmorillonite. The soils have high shrinkage and swelling characteristics and low shearing strength. These are highly compressible and have very low bearing capacity. It is extremely difficult to work with such soils. The California Bearing Ratio (CBR) is a measure of resistance of material to penetration of standard plunger under controlled density and moisture conditions. This test may be conducted in remoulded or undisturbed specimens in the laboratory. Many methods exist today, which utilize mainly CBR test values for designing pavement thickness requirement. In order to decrease the thickness of pavement we are going to increase the CBR value & ultimate bearing pressure value by UCC test by stabilizing the soil with polypropylene fibers which decreases the cost of laying of pavements & increase the bearing pressure

Keywords: Component; formatting; style; styling; insert (key words)

I. INTRODUCTION

Civil engineers are also concerned virtually with all aspects of environmental control, including water resources, water pollution control, waste disposal and containment, and the mitigation of such natural disasters as floods, earthquakes, landslides, and volcanoes. Here the soils and their interactions with the environment are major considerations. To properly deal with the earth materials associated with any project requires knowledge, understanding, and appreciation of the importance of formation, materials science and testing, and mechanics. Expansive soils in India are highly problematic, as they swell and shrink on evaporation. Because of this alternative swell and shrinkage, distress is caused on the foundation of structures laid on soils. Extensive research is going on to find the solutions for black cotton soils. The present paper consists of innovative solutions along with conventional foundation practice to counteract the dual problem of swelling and shrinkage posed by expansive soils. Swelling soils of India are commonly known as black cotton soils, because of their color and suitability for growing cotton. Expansive soils are one of the major regional deposits in India, covering an area of about 3.0 lakh sq.km. These are problematic soils because of their inherent potential to undergo volume changes corresponding to changes in moisture regime. These soils are colloidal soils containing two-micron clay fraction varying between 50%-70% consisting of significant portion of montmorillonite and illite minerals. These are regarded as problematic to geotechnical engineers because of their susceptibility to alternate swelling and shrinkage due to variation of moisture. Structures on these soils experience large scale damage due to heaving accompanied by loss of strength of these soils during rainy season and shrinkage during summer. These problems associated with expansive soils include heaving and cracking of structures such as foundations, retaining walls, foundations, pavements, canal beds and linings.

S.No.	Property	Value
1.	Dry Density γ_d	1300 to 1800 kg/m^3
2.	Fines(<75µ)	70 to 100%
3.	2µ Fraction	20 to 60 %
4.	Atterberg Limits Liquid limit L.L.(%) Plastic Limit P.L.(%)	50 to 120 20 to 60
6.	Soil Classification	CH or MH
7.	Specific Gravity, G	2.60 to 2.75
8,	Proctor Density, Max Dry Density Optimum moisture content	1350 to 1600 kg/m^3 20 to 35 %
9.	Free swell Index	40 to 180 %
10.	Swelling Pressure	50 to 800 kN/m^2
11.	C.B.R (Soaked)	1.2 to 4.0
12.	Compression Index	0.2 to 0.5

II. LITERATURE SURVEY

Several researchers had carried out investigations to judge the behavior of treated ground with chemicals or fibers alone. The literature on the topic of soil stabilization is reviewed in this chapter. Some papers dealing with experimental investigations on soil stabilization using randomly mixed fibers are discussed in the present chapter.

Kaniraj&Vasant (2001) studied fly ash –soil specimens compacted at the MDD-OMC state and they were found to exhibit brittle behavior in unconfined compression test. The brittle behavior is more marked in cement stabilized specimens than in un-stabilized specimens. The fibers inclusions change the behavior in both instances to ductile behavior. The increase in the unconfined compressive strength of un-stabilized fly ash-soil specimens due to fibers inclusions depends on the unconfined compressive strength of the unreinforced specimens. The unconfined compressive strength of a fly ash- soil mixture increases due to addition of cement and fibers. Depending on type of mix and curing period, the increase in unconfined compressive strength caused by the combined action of cement and fibers is either more than or nearly equal to the sum of the increase caused by them individually.

Kumar et al (2007) studied the addition of polyester fibers with lime, fly ash and sand was observed to stabilize and improve the geotechnical properties of clayey soils Lawtonet al. (1993) has shown that incorporation of polymeric multi-oriented geo-synthetic inclusions within sandy soils caused substantial improvements in strength and stiffness. Maher and Woods (1990) have shown that fibers increased the dynamic shear modulus and damping ratio of sandy soils subjected to dynamic resonant-column and torsion shear tests.

Maher and Ho (1994) indicated that the inclusion of fibers increased the hydraulic conductivity, splitting tensile strength, and flexural toughness index of clayey soils. Manoj and Prathap (2010) studied the effect of natural fibers mixed with soil. The natural fibers were effectively made use of provided they are given suitable treatment. In this paper, natural fibers like coir is selected and strength effect between uncoated and bitumen coated coir fibers are studied in terms of its compaction effort and strength.

Nelson and Miller (1992) investigated naturally occurring expansive clays change volume when subjected to variation in water content. This can result in considerable damage to foundations that are seated on these materials such as highways, bridges and buildings. Ozkul and Baykal (2006) used rubber fibers (tire buffing) in combination with low-plasticity kaolin clay and investigated the influence of fibers content on compaction behavior and shear strength of the mixtures. However, to the author's knowledge no research studies have been reported in the literature concerning the effect of nylon and Palmyra fibers on the swelling properties of clayey soils. The main objective of this study was to investigate the effect of different types of fibers (natural Palmyra and synthetic nylon) with four different aspect ratios (L/d) on the swelling properties of clayey soils. The natural Palmyra fibers are tough natural fibers obtained from the (African Palmyra) palm tree. The aspect ratio is defined as the ratio of the length to the diameter of the fibers. Ranjan et al (1996) have proposed a mathematical model based on statistical analysis to predict the shear strength of sandy soils reinforced with synthetic and natural fibers.

Sanjeev Kumar and Everett Tabor (2003) made a study by mixing nylon fibers with silty clay soil to investigate the relative strength in terms of unconfined compression. The results showed that the degree of compaction on amount of nylon fibers affected the relative benefits of the fibers reinforcement. Samples compacted at 93% maximum dry density showed higher increase in the peak and residual strengths compared to the samples compacted to higher densities. The effect of addition of nylon fibers is significantly higher on the residual strength of soil compared to the effect of peak strength. Strains at peak strengths increase with increase in amount of fibers.

III. MATERIALS AND METHODS

The stabilization of soils using polypropylene fibers is an old age practice and is popular method of soil stabilization owing to its availability. Low cost and applicability to wide range of soils. However from the literature review it is clear that only a few investigators considered the study of stabilization of silty sand soils using fly ash and polypropylene accounting for dry density and California bearing ratio of the soils. Further, the literature is scanty concerning the California bearing ratio characteristics of polypropylene fibers treated expansive soils …………………Present investigation aims at determining Optimum fiber content for stabilization of expansive soil by adding different types of fibers. Further, it is intended to study the possibility for improving properties of expansive soil using polypropylene fibers. To achieve the goals a series of tests are conducted in the laboratory. The details of the test procedures & index properties of fibers are given in the following sections.

IV. MATERIALS USED

In this section, the details pertaining to soil, polypropylene fibers used in this investigation are given.

Soil: The soil used in the present investigation is obtained from the place of komatigunta, Krishna district. The required amount of soil is collected from the trial pit at a depth of 9.0m below the ground level, since the top soil is likely to contain organic matter and other foreign materials. Sufficient care has been taken to see that the collected soil sample is fairly homogeneous. The soil so obtained is air dried, crushed with wooden mallet and passed through 4.75mm sieve. This soil so obtained is kept in polythene bags for further testing. The index properties of the soil are given in the Table 2.1. The 'soil' is classified as 'CH' as per I.S. classification (I.S. 1498:1970) indicating that it is high plastic clay.

Index properties of soil

S.No.	Property	Soil
1.	Moisture content	
2.	liquid limit	
3.	Plastic limit	
4.	IS Classification	CH
6.	Maximum dry density KN/m³	
7.	Optimum moisture content %	
8.	C.B.R (Unsoaked) %	
9.	Cohesion (C)	
10	Angle of friction (Ø)	
11	Ultimate Bearing capacity	

Synthetic fibers

When some fibers geotextile of high tensile strength is laid in soil, the engineering properties of soil are improved and the reinforced soil is known as fibers-reinforced soil. In the ancient time, some natural materials including wood, bamboo, reeds, wheat straw, and rice straw were used to improve the strength of soil. With the advent of synthetic fibers and its rapid development, plenty of synthetic fibers have been employed in many fields as innovative engineering materials, as well as main reinforcement agents for ground improvement.

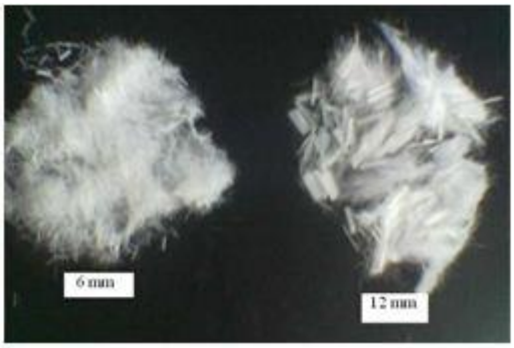


Figure..... Picture of loose 6mm and 12mm Polyester fibers

At present, the common types of synthetic fibers are carbon, steel, glass, asbestos, polyester, polyethylene, polypropylene, nylon and high-elastic-modulus polyvinyl alcohol fibers. In these artificial synthetic fibers, fibers is laid in the soil to improve the engineering properties of soil as geogrid or geotextile while a small quantity of short fibers is dispersed into concrete or asphalt as an additive to improve their strength. Polyester fibers of 6mm and 12mm length are used for the present study.

PHYSICAL PROPERTIES OF POLYPROPYLENE FIBER:

Tensile strength (gf/den)	3.5 to 5.5
Elongation (%)	40 to 100
Abrasion resistance	Good
Moisture absorption (%)	0 to 0.05
Softening point (ºC)	140
Melting point (ºC)	165
Chemical resistance	Generally excellent
Relative density	0.91
Thermal conductivity	6.0 (with air as 1.0)
Electric insulation	Excellent
Resistance to mildew, moth	Excellent

V. METHODOLOGY

a) Tested the material properties as per Indian standards code (IS: 383 –1996) procedures.
b) Tested the liquid limit test and plastic limit test as per Indian standard (IS: 2720-PART-5 -1985)
c) Tested the OMC and MDD by using light compaction test as per Indian standard (IS: 2720 –PART-7-1980)
d) Tested the bearing ratio value by CBR test as per Indian standard (IS: 2720-PART-16-1987)
e) Tested the shear strength by DIRECT SHEAR test as per Indian standard (IS: 2720-PART-13-1986)
f) Tested the specific gravity as per Indian standard (IS: 2720-PART-3-SECTION-2-1980)
g) Tested the grain size analysis as per Indian standard (IS: 2720-PART-4-1985)

COMPARISON OF NORMAL SOIL & 6MM FIBERS

Liquid limit & plastic limit:

	6mm fibers	
	Liquid limit(%)	Plastic limit (%)
Normal soil	74	36
1%	82	40
2%	77	30
3%	58	35
4%	75	40

Light Compaction

	6mm fibers	
	OMC	MDD
Normal soil	16	1.485
1%	16	1.69
2%	12	1.71
3%	14	1.79
4%	18	1.56

Direct Shear

	6mm fibers	
	C	Ø
Normal soil	0.34	65
1%	0.2	63
2%	0.18	62
3%	0.24	69
4%	0.2	68

COMPARISON OF NORMAL SOIL & 12MM FIBERS

Liquid limit

	12m fibers	
	LL	PL
Normal soil	74	36
1%	73	40

2%	69	60
3%	58	35
4%	77	45

Light compaction

	12m fibers	
	OMC	MDD
Normal soil	16	1.48
1%	18	1.69
2%	14	1.71
3%	18	1.79
4%	20	1.56

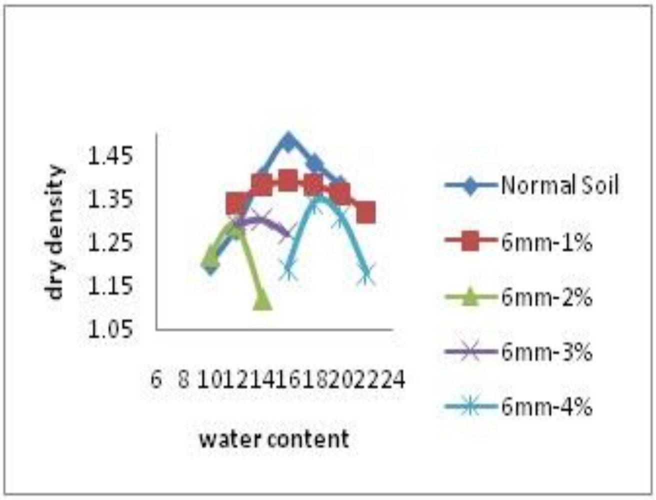
Direct Shear

	12m fibers	
	C	Ø
Normal soil		
1%	0.28	60
2%	0.1	65
3%	0.1	66
4%	0.26	55

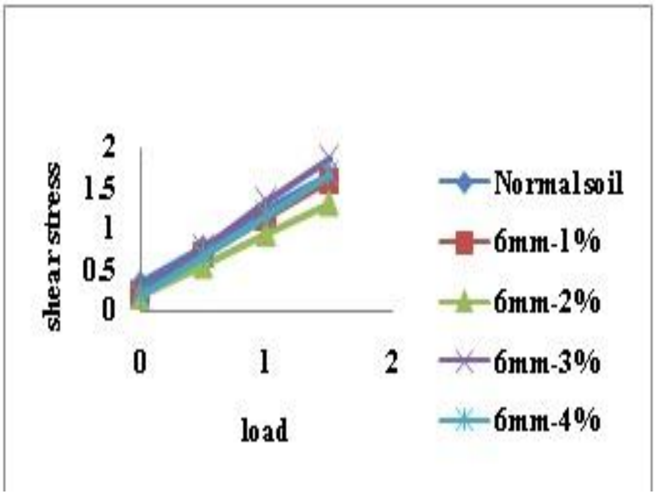
GRAPHS

COMPARISON OF NORMAL SOIL & 6MM FIBERS

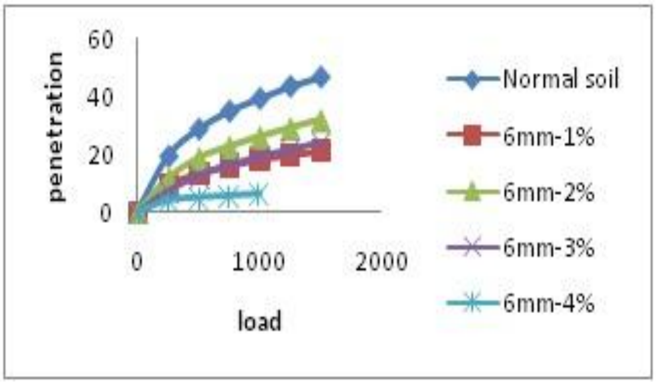
Light Compaction



Direct Shear

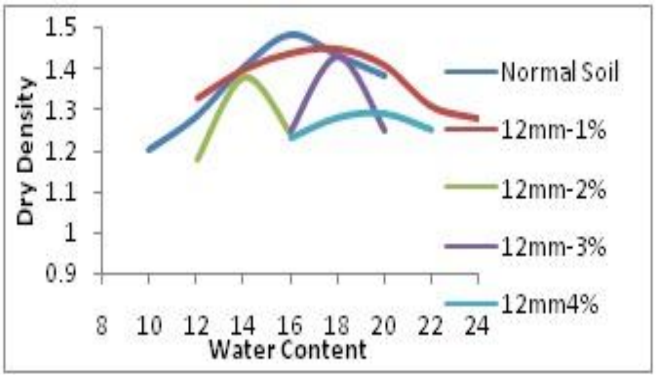


CBR

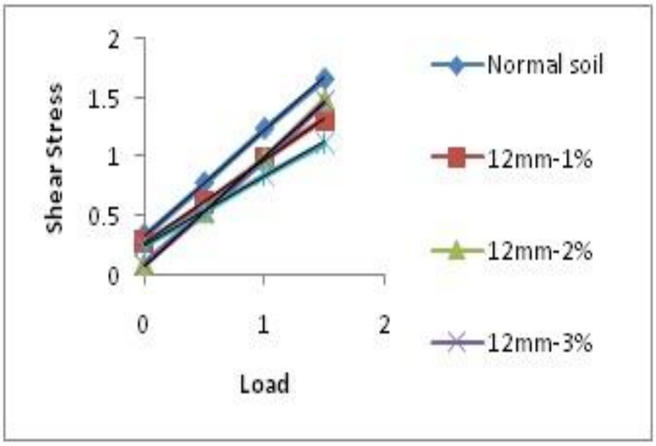


COMPARISON OF NORMAL SOIL & 12MM FIBERS

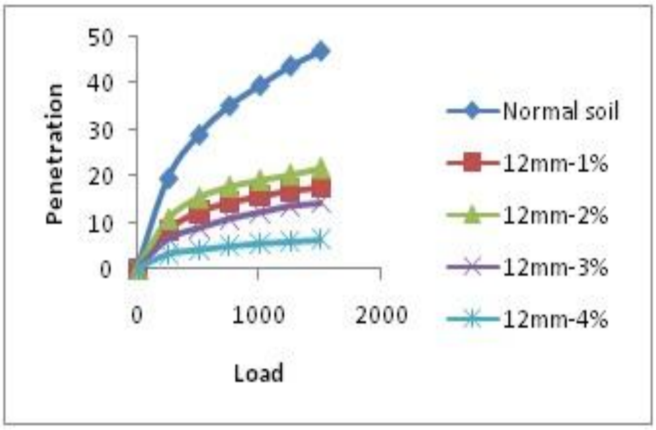
Light compaction



Direct Shear



CBR



VI. CONCLUSION

Expansive soils are most problematic soils. Change in the water content causes failure of structure constructed on this soil. These failures are reduced by changing the properties of the soil. For changing the behavior of soil, stabilization is the method evolved. This stabilization is done by using different materials like as quarry dust or stone dust as stabilizing agent. Some of properties like specific gravity, grain size distribution of soil are matched. So we had combined the soil and polypropylene fibers finding the index properties,OMC,MDD,CBR value, shear strength and $ value. If the percentage of adding polypropylene fibers to soil is up to 4% is done by doing so, from results we know that 3% polypropylene fibers as optimum content for this soil.

In initial state the soil is having liquid limit is greater than50%, Soil is at high compressibility clayey soil. After stabilization with quarry dust the soil properties are changed into the intermediate compressibility of clayey soil with liquid limit greater than 35% but less than 50%. Soil having low natural field density, after the compaction field density slight increased. After the stabilization with polypropylene fibers the density is increased gradually upto3%, after 3% the dry density is decreased. If the OMC of the soil is also decreasing up to 4% and the soil properties are changed due to adding of polypropylene fibers, Clay soil behavior changed into silty soils. Bearing capacity of soil is gradually increased and alaso quarry dust is giving good bearing capacity for Expansive clays. In general bearing ratio (CBR) will be 1.2 to 4, after stabilization the value of CBR reached to 2.5. The angle of shearing resistance and cohesion values are changed from local shear failure to general shear failure.

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