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Behavior of Soil Reinforced with Polypropylene Fibres

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Abstract: *Soil without proper improvement lacks desirable engineering characteristics. Stabilization of soil is an effective technique to modify the soil with desirable engineering characteristics. Stabilization using geosynthetic is very common now a days. The stabilization of cohesion less soil is made on soil to make sure that the soil is suitable for various geotechnical applications. Geofibre (fibrillated polypropylene) are extremely fine fibres are light weight material. They are capable of increasing bearing capacity of soil subgrades.The main objective of this study is to investigate the use of waste fibre materials in stabilization and to evaluate the effects of waste polypropylene fibres on shear strength of unsaturated soil by carrying out direct shear tests on two different soil samples.*

Key Words: *cohesion less soil, geofibre, stabilization*

1. INTRODUCTION

The foundation is very important in field of civil engineering to support and resist loads of entire structure. Therefore, a foundation should be strong enough to increase the service life of any structure. The foundation of structure directly depends on to the soil. So, it is mandatory to have proper knowledge about the physical and chemical properties of soil; and factors which affect their behavior. Some soils are not suitable for foundation work so these soils are stabilized to achieve the required properties needed for the construction work. The need of enhancing soil properties had came in light at the beginning of ancient constructions. In ancient times, Romans utilized various methods to improve soil strength etc. Some of these methods were so effective that their construction in buildings and roads still exist.

In India, the era of soil stabilization began in early 1970's. Shortage of petroleum and aggregates forced the engineers to look for other means to reinforce soil instead of replacing the poor soil at the site. In the modern era, the increase in the demand for infrastructure and resources, soil stabilization has started to take a new shape. Various researches are carried out on soil stabilization techniques and it is emerging as a popular and cost-effective method to improve soil properties.

Soil reinforced with fibers behaves as a composite material in which fibers improves the strength of soil. Shear stresses in the soil enhance tensile resistance in the fibers, which in turn provides greater strength to the soil. Therefore, laboratory and some in situ test results have led to positive conclusions proving the potential use of fibers for the reinforcement of soil mass. The concept of fiber reinforcement was developed in ancient times, more than 5000 years ago when ancient civilizations used straw and hay to reinforce mud blocks. However, short natural and synthetic fiber soil composites have recently gathered attention in the field of geotechnical engineering. The primary purpose of reinforcing soil mass is to improve its stability in order to increase its strength to resist deformations and shear failure. As it was mentioned, soil reinforcement is a procedure where natural or synthesized additives are used to improve the properties of soils. In present time, several reinforcement techniques are available for stabilizing problematic soils.

The main aim of this research is to study the effect of polypropylene fibre on the strength and stiffness of soil. A series of direct shear tests were carried out to evaluate the influence of PP fiber on cohesionless soil.

2. MATERIALS

A. Sea Sand

The soil used in this study is collected locally from Kazhakkuttom, Thiruvananthapuram district. The properties of the soil are studied using standard procedures and the results are tabulated in table. From the test results, the soil can be classified as Poorly Graded Sand according to Indian Standard Classification system.

Table -1: Properties of Sea sand

Properties	Result
D_{10} (mm)	0.300
D_{60} (mm)	0.460
D_{30} (mm)	0.370
Uniformity Coefficient, C_U	1.533
Coefficient of Curvature, C_C	0.992
Specific Gravity	2.64
Optimum Moisture Content(%)	9.01
Maximum Dry Density (g/cc)	1.68
Angle of Shearing Resistance	39^o
Cohesion (kg/cm^2)	0.2
Classification of soil	SP

B. River Sand

The soil used in this study is collected locally from Neyyar river banks, Thiruvananthapuram district. The properties of the soil are studied using standard procedures and the results are tabulated in table 2. From the test results, the soil can be classified as Poorly Graded Sand according to Indian Standard Classification system.

Table 2: Properties of River sand

Properties	Result
D_{10} (mm)	0.175
D_{60} (mm)	0.390
D_{30} (mm)	0.252
Uniformity Coefficient, C_U	2.228
Coefficient of Curvature, C_C	0.930
Specific Gravity	2.54
Optimum Moisture Content	10.9%
Maximum Dry Density (g/cc)	2.11
Angle of Shearing Resistance	40^o
Cohesion (kg/cm^2)	0.09
Classification of Soil	SP

C. Polypropylene fibres (PP Fibres)

The common synthetic fibres used are polypropylene fibre, glass fibre and nylon fibres. They are basically by-products of petroleum—thus exhaustive and relatively costly compared to natural fibres. Polypropylene is normally tough and flexible, especially when copolymerized with ethylene. This allows polypropylene to be used as an engineering plastic, competing with materials such as acrylonitrile butadiene styrene (ABS). Polypropylene is reasonably economical. Polypropylene has good resistance to fatigue. The Polypropylene fibres(12mm) were collected from Fibrezone India Navrangapura, Ahmedabad.

Table 3. Properties of polypropylene fibre

Behaviour parameters	Values
Fiber type	Single fiber
Unit weight	0.91 g/cm^3
Average diameter	0.034 mm
Average length	12mm
Breaking tensile strength	350MPa
Modulus of elasticity	3500MPa
Fusion point	165 ^{0} C
Burning point	590^0 C
Acid and alkali resistance	Very good
Dispersbility	Excellent
Aspect ratio	353

3. RESULTS AND DISCUSSIONS

A. Compaction

The strength of weak soils can be altered by the addition of PP Fibres in varying percentages. In the present investigation a series of compaction tests were carried out by varying PP Fibre waste. The effect of PP Fibre on OMC and MDD are shown in chart.1 and 2.

The data from the test indicates that the optimum moisture content of stabilized sediments is less than that of raw sediments. When River sand was reinforced with PP Fibre, the compacted sand-PP Fibre composite yielded 10.9% of OMC and also when sea sand was reinforced with PP Fibre ,composite yielded to a 9.01% of OMC. The maximum dry density was noted to decrease slightly with increase in addition of PP fibres.Random inclusion of fibres cause an increase in OMC and decrease in MDD. Fibres have a tendency to absorb moisture and this can be attributed to the increase in OMC on random fibre inclusion. Fibres have less unit weight. So binding of fibre in soil matrix causing a decrease in the maximum dry density.

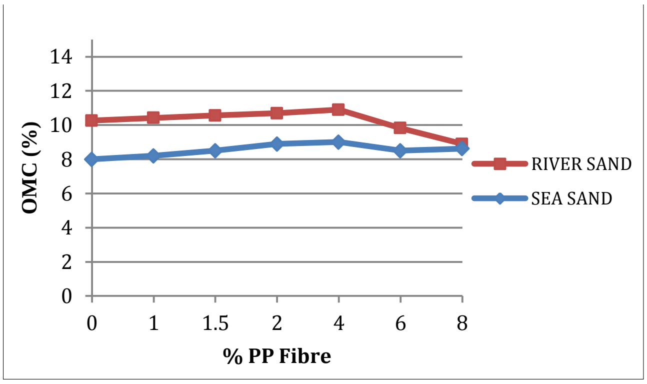

Chart 1: Variation of OMC with different percentages of PP Fibre

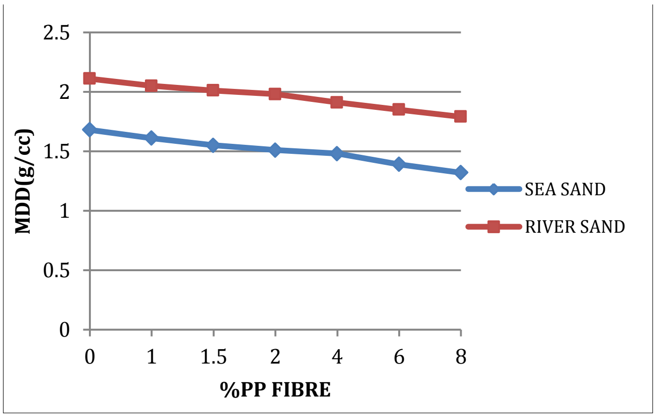

Chart 2: Variation of MDD with different percentages of PP Fibre

B. Shear Strength

The angle of shearing resistance (φ) increased exponentially with that of the addition of PP Fibres. Whereas, the cohesion (c) was noted to slightly increase and then decrease with further addition of PP Fibres. This result is consistent with results obtained by Nataraj (2016).

When the fibre content is low the space of fibre in soil increases. So there will be a difficulty to form effective net between soil and fibres. When the content of fibre increases the fibers become closer. This makes the adjacent fibre intersect easily to form the effective fibre-sand net to improve the cohesion and friction. On further increasing the fiber content the fibre filaments form clusters inside the sand sample to make the non uniform distribution of fibres. It is easy to form the weak area of stress due to the excess of fibres. So all the values of cohesion and friction angle of fibre reinforced samples increase with increasing fibre content upto an optimum limit and thereafter decreases.

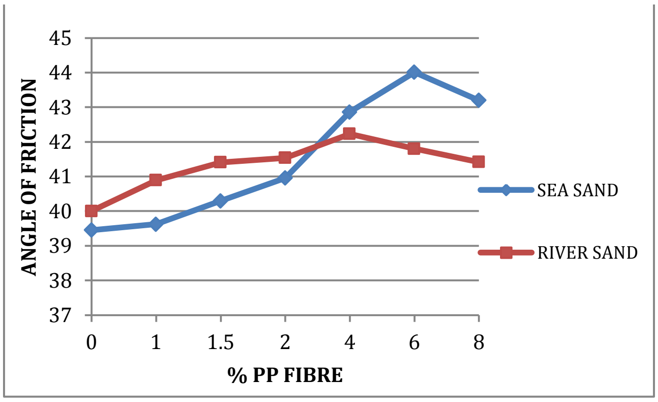

Chart 3: Variation of Friction angle with percentage PP fibre

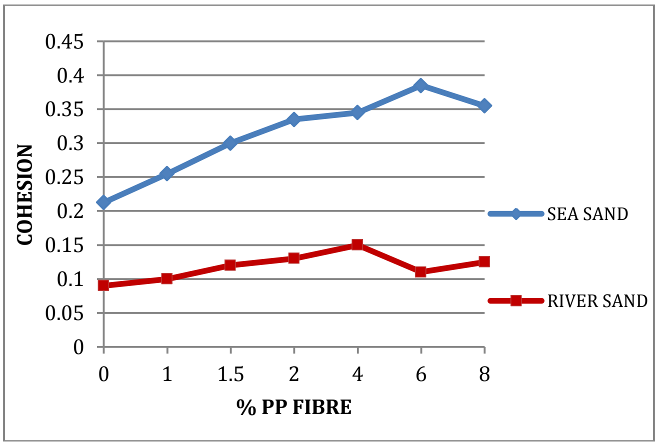

Chart 4: Variation of Cohesion with percentage PP fibre

4. CONCLUSIONS

•The test results from this study indicate that by reinforcing the two selected soils with 12 mm long fibrillated fibres, the optimum fibre content is 10.9% and 9.01% for river sand and sea sand of the dry unit weight of the soil specimen.

•Similarly there was a decrease in dry unit weight in both the specimens. It is 2.11 and 1.68 g/cc in river sand and sea sand respectively. The compressive strength of the soils increased with an increase in the moisture content up to the optimum moisture content.

•The direct shear test result indicates that there was a increase in friction angle when geofibre is added. It is due to the dense packing of sand fibre composite.

•There was a variation in cohesion when geofibre was added in both the sand specimens. It may be due to the orientation of fibre in the soil matrix.

•The mechanical interlock effect of the fibres provides increased tensile strength and cohesion to the soil matrix.

•The reinforcement mechanism has potential in the construction of highways and slopes.

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