International Journal of Engineering and Techniques - Volume 5 Issue 1, Jan-Feb 2019

RESEARCH ARTICLE OPEN ACCESS

Effect of Artificial Fiber on the Compaction and Strength Behavior of Shedi Soil

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Abstract:

Some of the beds in the coastal area do not show the behaviour of clay or silt, but when it comes in contact with water it flows like water, which will cause lot of settlement and this bed soil is termed as shedi soil. The construction of foundation for structures embankments, roads on shedi soil poses a challenge to civil engineers. Chemical stabilization is one of the oldest methods of stabilization for problematic soil. In recent days it has been investigated that addition of fibers will improve the ductility behaviour of the soil,thereby reducing the development of crack during shrinkage. Soil is reinforced with randomly distributed artificial nylon fiber as one combination and shedi soil with polypropylene fiber as another combination. Optimization of shedi soil reinforced with fibers were determined by conducting direct shear test.All the samples were preparing to their optimum moisture content and maximum dry density. Samples were intended to test immediately were tested immediately where as samples with ageing were kept in dissector for required period there after samples were tested in direct shear test under an normal stress of 100 kPa. Shedi soil reinforced with 0.8% randomly distributed nylon fiber (by weight of soil)as well as shedi soil reinforced with 0.8% randomly distributed polyproplyne fiber (by weight of soil) is found to be optimum.

***Keywords* — maximum dry density, optimum moisture content, randomly distributed fibers**.

I. INTRODUCTION

Indian terrain is formed by various types of soil depositions. Some of the soil formations exhibit problems for design and construction of civil engineering structures. Some of the problematic soils are as follows: Black cotton soils, occurring in Maharashtra, Gujarat, Madhya Pradesh, Karnataka, parts of Andhra Pradesh and Tamil Nadu. These are expansive in nature. On account of high swelling and shrinkage potential these are difficult soils to deal with civil engineering designs. Marine soils, occurring in a narrow belt all along the coast, especially in the Rann of Kutch. These are very soft and sometimes contain organic matter, possess low strength and high compressibility. Desert soils, occurring in Rajasthan. These are deposited by wind and are uniformly graded. Alluvial soils, occurring in the Indo-Gangetic plain, north of the Vindhyachal ranges. Lateritic soils, occurring in Kerala, South Maharashtra, Karnataka, Orissa and West Bengal.

Some of the beds in the coastal area do not show the behaviour of clay or silt, but when it comes in contact with water it flows like water, which will cause lot of settlement and this bed soil is termed as shedi soil. The construction of foundation for structure, construction of embankment, construction of road on shedi soil poses a challenge to civil engineers. Chemical stabilization is one of the oldest methods of stabilization for problematic soil. In recent days it has been investigated that addition of fibers will improve the ductility behaviour of the soil, there by reducing the development of crack during shrinkage. Both natural fibers like coir, jute, wood pulp and artificial fibers like nylon, polypropylene, geosynthetic fibers can be used as a reinforcing material to soil.

In order to understand the effectiveness of the fiber as a method of ground improvement, an attempt is made to study the effect of fiber on compaction and strength behaviour of lime treated shedi soil. To understand the ductility behaviour of these combinations stress versus strain behaviour of various combinations are studied.Several researchers are conducted lots of tests on the soil reinforced with artificial fibers some of them are Amin Chegenizedeh *et.al*(2011) says that, plastic fiber affects the compaction characteristics of composite soil. They concluded that, plastic fiber decreases the maximum dry density with increase in moisture content in soil. The optimum variation was observed at 0.3% of 25mm length plastic fiber in soil .Muthu kumar *et.al* (2012) says that, polypropylene fiber affects the swelling behaviour of expansive soil. They concluded that black cotton soil reinforced with 10 mm length polypropylene fiber increases the swelling potential of the soil. The optimum variation was observed at 0.75% of 10 mm length of fiber in soil

II. MATERIAL AND METHODS

T The soil used for present study has been obtained from Shedi gudda Mangalore, Karnataka state, India, from a depth of one meter below natural ground level. For this present research work soil passing through 425µ BIS sieve is used.The Properties of the soil is shown in Table.1.0 and Table 2.0 and soil is shown in plate 1.0

Plate 1.0 Shedi soil used for present investigation

Table 1.0 Physical properties of Shedi soil

PROPERTIES	RESULTS
Colour	Light pink
Specific gravity	2.41
Grain size analysis	
Fine sand (%)	00.00
Silt size fraction (%)	85.00
Clay size fraction (%)	15.00
Atterberg's Limits	
Liquid limit (%)	24.00
Plastic limit (%)	12.06
Shrinkage limit (%)	9.96
Plasticity index (%)	11.94
Classification of soil	Clay of lower compressibility
Compaction characteristics (Proctor method)	
Optimum moisture content (%)	11.18
Maximum dry density (kN/m³)	19.52

Shear strength parameters	
Angle of internal friction (Ø)	5°
Cohesion (c) (kN/m^2)	6.0
California bearing ratio value	
Soaked CBR (%)	3.8

Table 2.0 Chemical Properties of Shedi soil
[From K. V Manoj Krishna [M.E Thesis work]

CHEMICAL	COMPOSITION
Ph	5.42
Calcium (%)	0.002
Sodium (%)	0.039
Potassium (%)	0.0
Chloride (%)	0.008
Sulphates (%)	
SO_4	0.004
O_3	0.003

Nylon is a non-biodegradable synthetic material used for preparation of good quality yarns for various purposes. It possesses good mechanical properties when used as a soil reinforcement material.For present research work Nylon fiber were obtained from Nylon rope procured from market, Banglore, Karnata, India.The cost of nylon fiber per 1 kg is 85.Rs/-. Yarns of the nylon rope were separated and the fibres were cut to the length varying from 1-38 mm were taken with varying percentage by weight of soil and tests were conducted. The fiber sample is as shown in Plate 2.0

Plate 2.0 Nylon fiber used in present investigation

Polypropylene is a synthetic material extensively used for commercial packing applications and other purposes. From literatures, it possesses great strength and ductility when used in soil. For present research work polypropylene fiber from waste bags were used. The cost of polypropylene fiber per one kg is 40 Rs/-.The polypropylene fiber of length varying from 1-38 mm was taken with varying percentage by dry weight of soil and tests were conducted. Es Plate 3.0 indicates the fiber sample. The properties of the both fibers are indicated in the Table 3.0 . From that Table 3.0 it is observed that nylon fiber is higher density than polypropylene fiber and also both are free from water observation behavior.

Plate 3.0 Polypropylene fiber used in present investigation

Table 3.0 General properties of different fiber used

Type of fiber	Nylon	Polypropylene
Colour	Blue	White
Length(mm)	1-38	1-38
Thickness(mm)	0.80	0.57
Specific gravity	1.05	0.10
Density(kN/m^3)	1.10	1.01
Water absorption (%)	0.00	0.00
Cost of fiber per Kg	85	40

III.RESULTS AND DISCUSSIONS

Compaction of shedi soil reinforced with fibers

Compaction is a process by which the soil particles are artificially rearranged and packed together into a closer state of contact by mechanical means in order to decrease the porosity of the soil and thus increase its dry density. Compaction test is conducted by using specially made apparatus known as mini compaction apparatus. As per Shridharan and Shivapullaiah (2005), the results are 98% same as that of proctor compaction test results and also we are verified the results for shedi soil alone by conducting both the methods and it is found that results are almost one and the same. Hence for remaining experiments we are adopted mini compaction test procedure for determining the maximum dry density and optimum moisture content.

Fig.1.0 it is observed that, addition of randomly distributed nylon fiber in shedi soil decreases the maximum dry density and increases the optimum moisture content. This may be due to the replacement of higher density soil particles by lower density fiber.

Fig.2.0 it is observed that addition of randomly distributed polypropylene fiber in shedi soil decreases the maximum dry density and increases the optimum moisture content marginally, when compared with shedi soil alone. Similar trend were observed by Ramesh et.al (2010) . According to them, the decrease in maximum dry density may be due to replacement of higher density soil by lower density polypropylene fiber in the soil-fiber mixture.

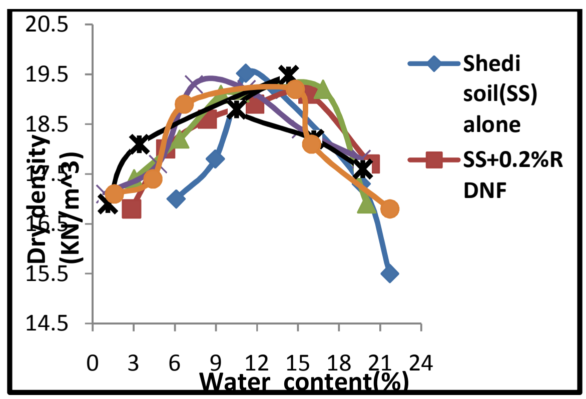

Fig.1.0 Variation of Dry density versus Water content for Shedi Soil reinforced with varying percentage of randomly distributed Nylon fiber.

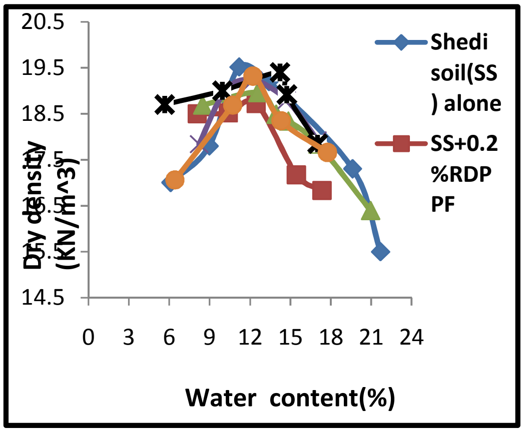

Fig.2.0 Variation of Dry density versus Water content for Shedi Soil reinforced with varying percentage of randomly distributed polypropyline fiber

Optimization of Shedi soil reinforced with various fibres

The optimum percentage of coir, jute, nylon and polypropylene fibers in shedi soil is decided based on the direct shear test.Direct shear test is conducted under a normal stress of 100 kN/m^2 with a strain rate of 1.25 mm/min by preparing samples to there optimum moisture content and maximum dry density. Shedi soil is added with various percentages of fibers (by weight of soil) and samples were prepared at their optimum moisture content-maximum dry density. Samples which are intended to test to know the immediate effect were test on the same day of the preparation of samples, where as samples which are intended to know the behaviour with time effect are kept in desiccators for various curing periods and then test in the same machine under same loading condition and the results are as discussed below.

The shear strength of the soil is resistances to deformation by continuous shear displacement of soil particles or on masses upon the action of a shear stress. Shear strength is determined by Direct shear test for our research work. Direct shear test is conducted as per IS: 2720 Part-13, 1986 guidelines.

All the direct shear test were conducted by preparing various combination of Shedi soil-lime, Shedi soil-randomly distributed nylon fiber and polypropylene Normal stress of 100 kPa is applied to the specimens of various combinations both with immediate and 7, 30, 45 and 60 days of curing period.

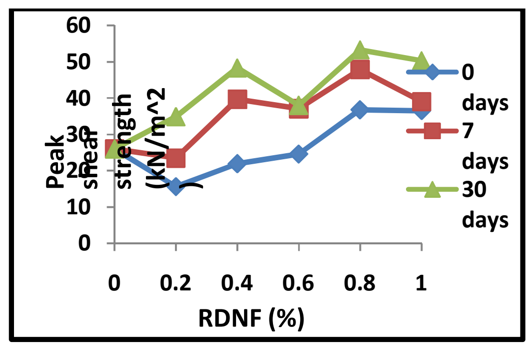

Fig.3.0Variation of shear stress with respect to varying percentage of randomly distributed nylon fiber.

Fig.3.0, it is observed that, on compare to shedi soil alone, addition of randomly distribute nylon fiber to shedi soil increases the strength up to 0.8% and beyond 0.8% nylon fiber content in the matrix, strength reduces. The increase in strength may be due to friction between the soil particles and fiber surface interaction up to 0.8%. Beyond 0.8% nylon fiber content in the matrix, reduces the strength as there is a fiber- to- fiber interaction in the matrix dominates rather than soil-to-fiber interaction.. From above discussion shedi soil reinforced with 0.8%randomly distributed nylon fiber (by weight of soil) is found to be optimum.

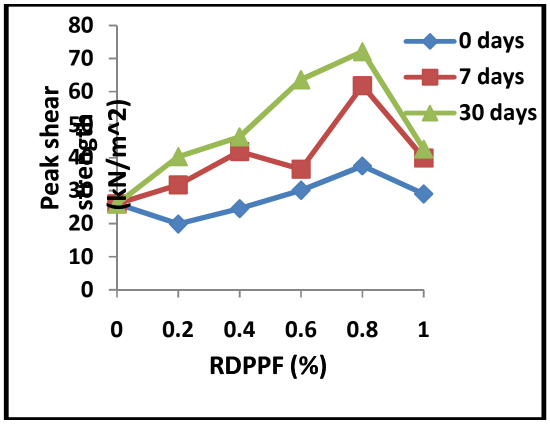

Fig.4.0 Variation of shear stress with respect to varying percentage of randomly distributed polypropylene fiber.

Fig.4.0, it is observed that, on compare to shedi soil alone, addition of randomly distribute polypropylene fiber to shedi soil increases the strength up to 0.8% and beyond 0.8% fiber content in the matrix reduces the strength. Similar trend were observed by Pradan et.al (2012) . According to them, increase in strength mainly due to increase in the surface area of polypropylene fiber. However the increased surface area of polypropylene fiber in matrix leads to increase in strength as the friction developed between soil particles and surface area of fiber in mixture up to 0.8%. Beyond 0.8%, there will be fiber to fiber interaction develops and leads to decrease in strength. From above discussion, shedi soil reinforced with 0.8%randomly distributed polypropylene fiber (by weight of soil) is found to be optimum.

Comparative shear strength study of shedi soil reinforced with artificial fibers

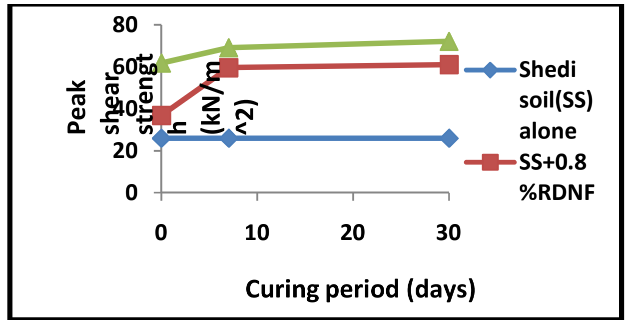

Fig.5.0 Variation of peak shear strength of shedi soil reinforced with optimum percentage of artificial fibers with curing (30days)

From Fig.5.0, it is observed that, addition of varying percentage of artificial fiber to shedi soil increases the peak shear strength on compared to shedi soil alone. Shedi soil reinforced with optimum percentage of randomly distributed nylon fiber has higher peak shear strength compared to soil reinforced with optimum percentage of randomly distributed polypropylene fiber. From the above graph it is observed that shedi soil reinforced with randomly distributed polypropylene fiber having 180% more strength carrying capacity at 30days curing on compared with shedi soils reinforced with randomly distributed nylon fiber at the same curing period.

Ductility behavior of shedi soil reinforced with artificial fibers

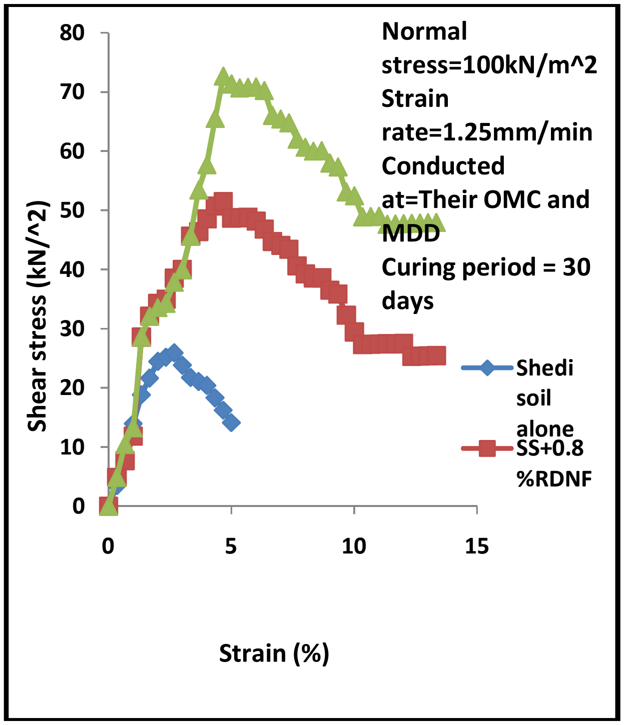

Fig. 6.0 Stress-strain behaviour of shedi soil reinforced with optimum percentage of artificial fibers with curing (30days)

Plate 4.0 Indicates shedi soil reinforced with optimum % of fiber after failure sample

From Fig. 6.0, it is observed that, strain at post peak fail of shedi soil alone is 5%. On addition of artificial fibers nylon and polypropylene, strain is increased by 14%. This is increased by 2.6 folds more on compared to shedi soil alone. This indicates it exhibits ductile behaviour in soil-fiber combination. Typical soil reinforced with fiber after failure is shown in plate.4.0

IV. CONCLUSIONS

Based on experimental work followed by technical analysis of the results, following conclusions were drawn, they are as follows:

1. Shedi soil reinforced with 0.8% RDNF(by weight of soil) and shedi soil reinforced with 0.8% RDPPF(by weight of soil) shows higher maximum dry density compared to other fiber combination.
2. Shedi soil reinforced with 0.8% randomly distributed nylon fiber(by weight of soil)and shedi soil reinforced with 0.8% randomly distributed polypropylene fiber (by weight of soil) shows higher strength on compared with shedi soil alone as well as with other percentage of fibre combinations on tested with both immediate as well as withvarious curing periods. This indicates that above combinations will induce optimum shedi soil-fiber matrix induces higher soil-fibre friction compared to other percentage of fibre combination to shedi soil. Hence these are found to be optimum combinations.

3. Shedi soil reinforced with randomly distributed polypropylene fiber having 180% more strength carrying capacity at 30days curing on compared with shedi soils reinforced with randomly distributed nylon fiber at the same curing period.
4. Addition of artificial fiber to shedi soil improves the stress – strain behavior of soil. Presence of fiber in the shedi soil changes the post peak failure pattern from brittle to ductile in nature.
5. Shedi soil reinforced with optimum fibers(either nylon or polypropylene fiber) ductility behavior increases by 2.6 folds on compared with shedi soil alone.

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NOTATIONS

Kpa= Killo Pascal

MDD=Maximum Dry Density

OMC=Optimum Moisture Content

RDNF= Randomly Distributed Nylon Fabre

RDPPF= Randomly Distributed Polypropyline Fibre

SS=Shedi Soil