FIBRE REINFORCEMENT OF SANDY SOIL

Deeba Qadir [1] , Sabreena Mohammad [2], Sarmistha R.Paul [3]

[1,2] M.Tech student Sharda University, Greater Noida (India)

[3]Assistant Professor Civil Engineering Department, Sharda University Greater Noida (India)

ABSTRACT

The word sandy soil represents a soil which consists of more amount of sand particles and small amount of clay and silt particles. Sandy soils have fewer loads bearing capacity, less shear strength, less specific surface and they do not have any plasticity. Therefore, the cohesionless soil is mostly settled during earthquake and in heavy rainy season. Owing to such properties of cohesionless soil, it is very difficult to carryout construction work on such soil in a normal way. Several techniques are available for improving the strength of soils for using them as construction materials. Fibre reinforced soil is one of the modern techniques in which fibres of desired type and quantity are added to the soil, mixed uniformly in random directions and then laid in position. . It is one of the most popular techniques used for the improvement of poor soils. Further, soil reinforcement causes significant improvement in tensile strength, shear strength, bearing capacity as well as economy. This study involves possible use of polypropylene fibre for soil stabilization. The analysis was done by conducting Grain Size Analysis, Proctor Compaction tests and unconfined compression tests and determination of consistency limit, specific gravity on un-reinforced as well as reinforced soil samples to investigate the strength characteristics of fiber-reinforced soil. These tests are to be conducted at both non-stabilized and stabilized states by adding 0%, 0.5%, 1%, 1.5%, and 2% of polypropylene fibre by weight of the soil sample. The results show the effect of polypropylene fibre on geotechnical properties of the soil samples. As the polypropylene fiber produce the tensile property, it helps in the increase of strength of sandy soil. Reinforced soil is really an attractive and economical answer to many earth retention problems associated with highway construction, such as retaining walls, bridge abutments, platform supporting structures, foundation slabs, under water quay and sea walls, dams, sedimentation basins and tunnel linings.

Keywords: Unconfined Compressive Strength, Proctor Compaction test, reinforced soil

1. INTRODUCTION

Soil is a naturally occurring component either loose or dense deposit produced as a result of weathering or disintegration of rock formation or decay of vegetation, intermingled together. There is a variety of natural soil material found in Mother Nature's womb. In India large deposits of cohesionless soil are observed. Cohesionless soil is defined as the soil which is not containing water and the shear strain does not exist (or is negligible) between two particles. Loose and sandy material in which there is no bond between the particles is also termed as cohesionless soil. Cohesionless soil is also known as frictional soil. Cohesionless soil have less load bearing capacity, less shear strength, less specific surface and they do not have any plasticity. Therefore, the cohesionless soil is mostly settled during earthquake and in heavy rainy season. Owing to such properties of cohesionless soil, it is very difficult to carryout construction work on such soil in a normal way. Here, need is felt to find some problems encountered during construction on cohesionless soil and methods for prevention of these problems. Recently soil reinforcement is an effective and reliable technique for improving strength and stability of soils. The concept of earth reinforcement is an ancient technique and demonstrated abundant in nature by animals, birds and the action of tree roots. The nature is the best example of earth reinforcement. In nature, the roots of plant and trees hold the earth during heavy rain and cyclone. This reinforcement resists tensile stress developed within the soil mass thereby restricting shear failure. Reinforcement interacts with the soil through friction and adhesion. The inclusion of randomly distributed discrete fiber increases strength parameters of the soil same as in case of reinforced concrete construction.

In our present study, soil stabilization has been done with the help of randomly distributed of polypropylene fibre. The improvement in the shear strength parameters has been stressed upon and comparative studies have been carried out using different methods of shear resistance measurement. The important engineering applications of these materials are to serve as a backfill for mechanically stabilized walls and reinforced soil slopes, foundations and road pavements. For these engineering applications, the friction angle and the dilation angle of the sand are the most important engineering parameters. Fine sand induces greater porosity, water retention and resistance to penetration than coarse sand, they exhibit lower permeability. Porosity decreases when the heterogeneity of the sand grain distribution increases leading to an increase in resistance to penetration and decreases in permeability. The presence of silt particles leads to similar consequences. Thus silty sands are more compact than sandy soils, most silt particles occupying the voids between sand grains thereby reducing porosity and consequently permeability. The type clay and silt minerals present in sandy soil have great impact on availability of nutrients to the crops.

II LITERATURE SURVEY

Abdi et al. (2008) worked on fibre reinforced soils and concluded that consolidation settlements, swelling and crack formation reduces substantially. They have also reported that the hydraulic conductivity increased slightly by increasing fibre content and also with the length of fibre in the mix.

Prabhakar and Sridhar (2002) randomly distributed sisal fibre as reinforcement in a c-ϕ soil at four different percentages of fibre content, i.e. 0.25, 0.5, 0.75 and 1% by weight of raw soil and four different lengths of fibre, i.e. 10, 15, 20 and 25 mm and found significant improvement in the shear strength parameters (c and ϕ) of the soil.

Shivanand Mali Soft silty or clayey soils are extensively distributed worldwide and they can be improved with reinforcement in the form of randomly distributed fibers of natural and synthetic types. Among the natural fibers, coir and jute are produced in large quantities in South Asian countries. Polypropylene, polyester, polyethylene and glass fibers are widely available synthetic fibers. It is necessary to determine the optimum fiber content and fiber length for any fiber type in the laboratory prior to field applications. This paper reviews the strength behavior of cohesive soils reinforced with coir fibers, polypropylene fibers and scrap tire rubber fibers as reported from experimental investigation, that includes triaxial, direct shear and unconfined compression tests.

Gray and Al-Refeai (1986) reported that reed fibers were superior to glass fibers due to greater surface friction properties. They also indicated that sands stabilized with fiber contents >2% dry weight of sand achieved no added benefit (Ranjan et al. 1996).

III MATERIALS

The Following materials are used in the study for the stabilization of soil

3.1 Sandy Soil:

Sandy soil sample was collected locally from Uttar Pradesh state of India. The soil was taken from 1m depth from the natural ground surface and soil is air dried and after oven dried at 1100^0C before testing.

3.2 Fibre:

Polypropylene was introduced to the textile arena in the 1970s and has become an important member of the rapidly growing family of synthetic fibres. Today Polypropylene enjoys fourth spot behind the "big three" fibre classes, i.e. polyester, nylon and acrylic.

Table 1: Physical and Chemical properties of Fiber used

Physical and chemical properties	Values
Fibre type	Single fiber
Unit weight	0.91g/cm^3
Average diameter	0.034mm
Average length	12mm
Breaking tensile strength	350Mpa
Modulus of elasticity	3500Mpa
Fusion point	16^0C
Burning point	590^0C
Acid and alkali resistance	Very good
Dispensability	Excellent

IV METHODOLOGY

Following laboratory tests are carried out as per IS: 2720.The tests are to be carried out both on natural soil and stabilized soil with polypropylene fibers. The amount of polypropylene fibers for stabilization is taken in the proportion of 0.5%, 1%, 1.5% and 2% by dry weight of soil.

4.1 Specific gravity

It is defined as the ratio of the unit weight of the soil to the unit weight of water. The specific gravity is used in the computations of most of the laboratory tests, and is needed in nearly all pressure, settlement, and stability problems in soil engineering. It is an important property that is also helpful in classifying soils and in finding other weight-volume properties like void ratio, porosity, and unit weight.

Table 2: Expected values for Gs

Type of soil	Gs
Sand	2.65-2.67
Silty sand	2.67-2.70
Inorganic clay	12.70-2.80
Soils with mica or iron	12.75-3
Organic Soils	<2

From the specific gravity test performed in laboratory, specific gravity came out to be, G =2.67

4.2. Grain size analysis

Conducting sieve analysis test the soil is classified as: By AASHTO Classification Chart, it lies under the range of A-3 group, And by Unified soil classification system (USCS) and IS Classification system the soil is classified as SM (Sand- Silt Mixture).

4.3. Atterberg limit test

The liquid limit of a soil is the moisture content, expressed as a percentage of the weight of the oven-dried soil, at the boundary between the liquid and plastic states of consistency. The liquid limit is obtained from the plot corresponding to 25 blows, came out to be 20.2%.

4.4. Proctor Compaction test

Proctor compaction test is a laboratory method of experimentally determining the optimum moisture content (MDD) at which a given soil type will become most dense and achieve its maximum dry density (MDD). The amount of polypropylene fibers for stabilization is taken in the proportion of 0.5%, 1%, 1.5%, and 2% by dry weight of soil. The tests provide the following results, the optimum moisture content and maximum dry density of normal sandy soil and also soil mixed with fibers in different percentage.

Table 3: Proctor Compaction test of Polypropylene Fiber mix with Sandy soil

PERCENTAGE OF FIBRE	MAXIMUM DRY DENSITY (g/cc)	MOISTURE CONTENT (%)
Normal sandy soil	1.873	16.23
Sandy soil + 0.5% fibre	1.791	20
Sandy soil + 1% fibre	1.783	24.9
Sandy soil + 1.5% fibre	1.779	25.6
Sandy soil + 2% fibre	1.678	27.8

4.5 Unconfined Compressive Strength test

The unconfined compression test is by far the most popular method of soil shear testing because it is one of the fastest and cheapest methods of measuring shear strength.

Table 4: Unconfined Compression Test of Polypropylene Fiber mix with Sandy soil

PERCENTAGE OF FIBRE	UNCONFINED COMPRESSIVE STRENGTH (Mpa)
Normal sandy soil	0.0955
Sandy soil + 0.5% fibre	0.25
Sandy soil + 1% fibre	0.418
Sandy soil + 1.5% fibre	0.596
Sandy soil + 2% fibre	0.49

V RESULTS AND DISCUSSIONS

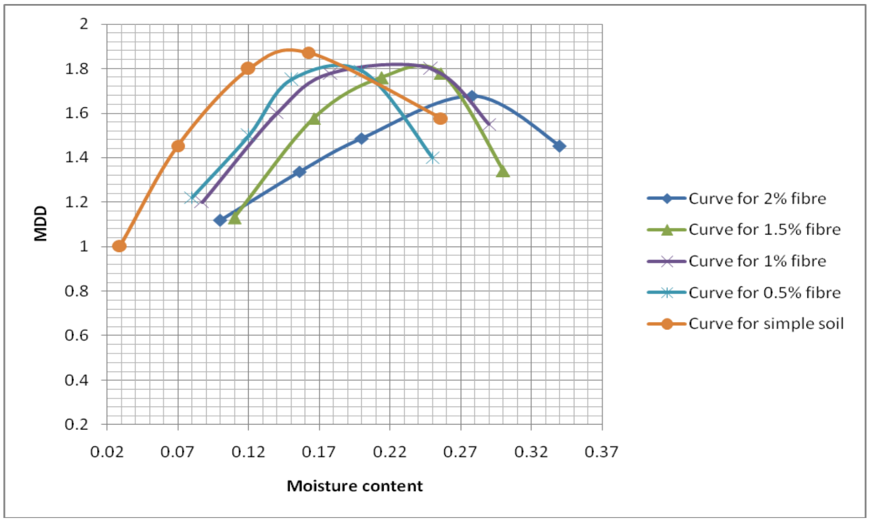

Figure1: Maximum dry density and optimum moisture content for different percentage of Polypropylene fibres in Sandy soil

Fig 1. It can be clearly indicated that by increasing in the percentage of polypropylene fibers in sandy soil the maximum dry density value decreases and the optimum moister content value increases, this is due to the fiber unit weight is very less comparatively and less then water and it replace the amount of soil while compaction and water taken for compaction is also more.

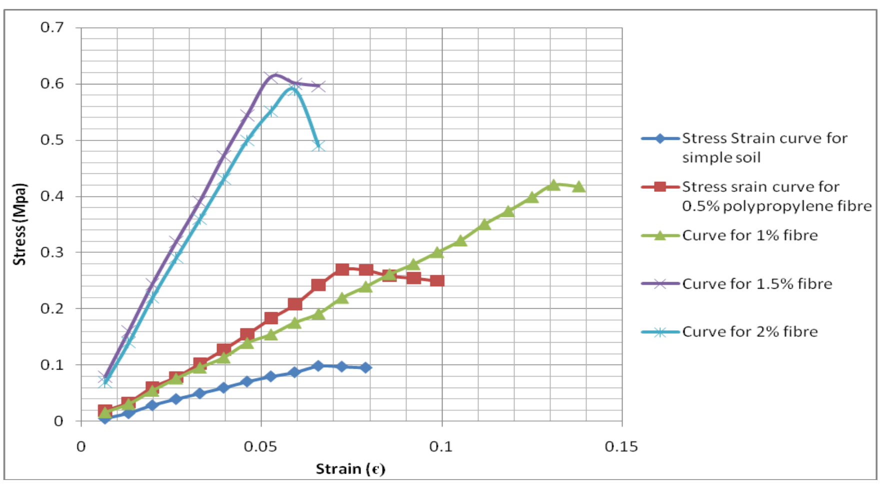

Figure 2: Stress strain curves for different percentages of polypropylene fibres

Fig 2. Shows normal soil and polypropylene fiber mixed with sandy soil. From the unconfined compression strength test results, it can be seen that by increasing the fiber percentage there is gradual increase in UCS value in sandy soil and fiber mix. But in 1% of polypropylene fiber mix with sand soil shows very good UCS value compared with normal soil and other fiber mixes

VI CONCLUSION

From the above experimental results it can be concluded that the fiber is very good in improving the engineering property of the sandy soil as well as shear strength and also plasticity by increase of the percentages of fiber. Chemical binding occurs between minerals in the soil and chemical elements in polypropylene fibers.

1. A series of compaction test were performed to evaluate the effect of fiber inclusion on optimum moisture content (OMC) and maximum dry density (MDD) of sandy soil. Increasing in fiber percentage increased OMC of sandy soil samples and decreased maximum dry density.
2. The unconfined compressive strength test results in increasing the angle of internal friction of sand and ductility of sandy soil. The polypropylene fiber shows good result in 1% mix with sandy soil. For example, unconfined compression strength increased from 0.25MPa to 0.418 Mpa for sample reinforced with 1% fiber. The fiber reinforced soil exhibits more ductile behavior than unreinforced soil.

Overall it can be concluded that fiber reinforced soil can be considered to be good ground improvement technique specially in engineering projects on weak soils where it can act as a substitute to deep/raft foundations, road pavement, reducing the cost as well as energy.

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