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Sub grade modification using natural coir fibres

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Abstract: Clayey and silty soils have lower permeability that can influence the construction of embankments and sub-grades for roadways and rail-tracks. It is found that natural fibers of coir made from processed husk of coconuts can be used effectively in the improvement of sub grade strength mainly due to enhanced consolidation as a result of accelerated drainage of moisture due to presence of coir fibers. Randomly distributed fiber reinforced soil is among the latest ground improvement techniques in which fiber of desired types and quantity are added in the soil, mixed randomly and laid in position after compaction. Inclusion of randomly distributed fiber makes the soil mass homogeneous and maintains the isotropy in strength. The natural fiber reinforcement causes significant improvement in compressive strength, shear strength, and other engineering properties of the soil. Over the last decade the use of randomly distributed natural and fiber has recorded a tremendous increase. Keeping this an experimental study was conducted on locally available soil reinforced with coir fiber.

Keywords: component, formatting, style; styling, insert

I. Introduction

In a developing country such as India, road networks form the arteries of the nation. A pavement is the layered structure on which vehicles travel. It serves two purposes, namely, to provide a comfortable and durable surface for vehicles, and to reduce stresses on underlying soils. In India, the traditional system of bituminous pavements is widely used. Locally available cement concrete is a better substitute to bitumen which is the by product in distillation of imported petroleum crude. It is a known fact that petroleum and its by-products are dooming day by day. Whenever we think of a road construction in India it is taken for granted that it would be a bituminous pavement and there are very rare chances for thinking of an alternative like concrete pavements. Within two to three decades bituminous pavement would be a history and thus the need for an alternative is very essential. Fibre reinforced concrete is defined as a composite material consisting of concrete reinforced with discrete randomly but uniformly dispersed short length fibres. The fibres can be made of steel, polymer or natural materials. Woven fabrics, long wires, bars, and continuous wire mesh are not considered discrete fibres. Fibre reinforced concrete is considered as a material of improved properties and not as reinforced cement concrete whereas reinforcement is provided for local strengthening of concrete in tension region. Since in Fibre reinforced concrete, fibres are distributed uniformly in concrete, it has better properties to resist internal stresses due to shrinkage. As fibres improve specific material properties of the concrete, impact resistance, flexural strength, toughness, fatigue resistance, ductility also improves.

II. Ease of Use

1 Soil Stabilisation

Stabilisation, is a broad sense, incorporates the various methods employed for modifying the properties of a soil to improve its engineering performance. Stabilisation is being used for various engineering works, the most common application being in the construction of road and air field pavements where the main objective is to increase the strength or stability of soil and to reduce construction cost by making best use of the locally available materials. Methods of stabilisation may be grouped under two main types:

a) Modification or improvement of soil property of the existing soil without any admixture,

b) Modification of the properties with the help of admixtures.

Compaction and drainage are the examples of the first type, which improve the inherent shear strength of the soil. Examples of the second type are:

1) Mechanical Stabilisation

2) Stabilisation with cement
3) Lime stabilisation
4) Bitumen stabilisation
5) Chemical stabilisation
6) Stabilisation by heating
7) Electrical stabilisation
8) Stabilisation using fibers

2. Fibers

Fiber is a small piece of reinforcing material possessing certain characteristics properties. They can be circular or flat. The Fiber is often described by a convenient parameter called "aspect ratio". The aspect ratio of the Fiber is the ratio of its length to its diameter. Typical aspect ratio ranges from 30 to 150.

2.1 Types of Fibres

A wide variety of Fibres have been used in concrete. For each application it needs to be determined which type of Fibre is optimal in satisfying the concrete application. The different types of Fibres used as concrete reinforcement are synthetic Fibres and steel Fibres. The different types of synthetic Fibres used are Polypropylene, Nylon, Polythene, Polyester and Glass Fibres.For architectural and decorative concrete products and for prevention of early age cracking, synthetic Fibres may be used. Steel Fibres are used for applications where properties of concrete in the hardened stage have to be modified, namely, post crack flexural strength, abrasion resistance, impact resistance and shatter resistance of concrete.

3. Objective & Scope

3.1 Objectives

The objective of the present study is to study the performance of the coir fiber as a filler component in embankment material without chemical stabilizers like lime or gypsum.

3.2 Scopes

The scopes of work for the present study are summarized below:-

Scope of this study is to perform a detail laboratory analysis on the consequences of the application of coir fiber by varying its percentage in order to observe the variation of various values. To achieve this, the study plan was divided into the following stages.

i. Collection of the coir fiber and locally available sand.
ii. Determination of index properties of the coir fiber and sand.
iii. Preparation of fill material sample without coir fiber and find out their standard properties.
iv. Preparation of test samples with different proportion and determination of compaction characteristics.
v. Calculation and comparison of test results to obtain a solution.

III. Materials Used

1. Soil

Reinforced soil is one of the techniques of ground improvement, the concept of which was first given by Vidal of France in 1966. Since then significant advances have been made in the design and construction of geotechnical structures such as retaining walls, foundations, embankments, pavements, etc. The function of the reinforcements in the soil matrix is to increase the strength (shearing resistance) and reduce the deformation. The primary advantages of randomly distributed fibers are the absence of potential planes of weakness that can develop parallel to oriented reinforcement (Maher and Gray 1990).The characteristics of soil can be found by conducting Atterberg's limits test and by sieve analysis. The procedure for those tests are as follows:

2. Liquid Limit

2.1 Scope

The liquid limit of soil is the water content, expressed as a percentage of the weight of the oven dried soil, at the boundary between the liquid and the plastic state. The water content at this boundary is arbitrarily defined as the water content at which two halves of a soil cake will flow together for a distance of 12-mm along the bottom of the groove separating the two halves, when the cup is dropped 25 times for a distance of 1 cm at the rate of 2 drops/s.

2.2 Sample Preparation

Place the soil sample, weighing about 250 g, from the thoroughly mixed portion of the material passing the 425-μm sieve obtained in accordance with the used standard in a porcelain evaporating dish (about 114-mm in diameter) and thoroughly mix with 15 to 20 ml of distilled water by alternately and repeatedly stirring, kneading, and chopping with a spatula. Mixing can also be done on a glass plate in the case care shut be taken to keep the hole sample at the same moister content. Make further additions of water in increments of 1 to 3 ml. Thoroughly mixes each increment of water with the soil as previously described, before adding another increment of water.

FIG 1. sample preparation

2.3 Procedure

Take about 200g of the given soil sample passing through 425micron sieve and desired quantity of water Mix the soil and water thoroughly Place the mixed paste in the liquid limit device almost half failed Level it with help of spatulaWith the help of grooving tool paste in cup is divided along the cup diameter by holding the total normal to the surface of the cup and dropping it firmly Turn to handle the apparatus at the rate of 2 revolutions per second Continue until the two parts of the soil come in contact with the bottom of the groove along a distance of 10 mmRecord the number of blows required to cause the groove to close for approximately a length of 10mm Continue the experiment by varying the water content

2.3.1 Plastic Limit

2.3.1.1 Scope of the Test

The plastic limit is often used together with the liquid limit to determine the plasticity index which when plotted against the liquid limit on the plasticity chart provides a means of classifying cohesive soils. It is the empirical established moisture content at which soil becomes to dry to be plastic.

2.3.1.2 Sample preparation

20 gram of material is needed. The sample may be a disturbed sample. We only use material passing the 425 μm sieve.

2.3.1.3 PROCEDURE

Clean the empty pan and weigh it (W1) Take small quantity of given soil sample and mix thoroughly with water till it becomes plastic .Roll the soil on a glass plate to make threads of 3mm dia .
Place the rolled threads of soil in the weighted pan and weigh the pan and wet threads of soil (W2)

Keep the pan in the oven and allow it to dry and again weigh the pan with dry threads of soil

Table 1 Atterberg's Limit

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index
37	18	19

2.3.2 Sieve Analysis

2.3.2.1 Scope Of The Test

If a soil contains silt or clay, or both, even in small quantities, it is necessary to carry out a wet sieving procedure in order to measure the proportion of fine material present. Even when dry, fine particles of silt and clay can adhere to sand-size particles and cannot be separated by dry sieving, even if prolonged. Washing is the only practicable means of ensuring complete separation of fines for a reliable assessment of their percentage.

If clay is present, or if there is evidence of particles sticking together, the material should be immersed in a dispersant solution before washing. The dried representative sample is spread out on a tray and covered with water containing 2g/litre of sodium hexametaphosphate. The soil is allowed to stand for at least an hour, and is stirred frequently. This disperses the clay fraction, so that clay and silt will not adhere to larger particles. The procedure is described in detail below for non-cohesive soils containing little or no gravel.

2.3.2.2 Sample Preparation

The specimen to be used for the test is obtained from the original sample by rifling, or by subdivision using the cone-and-quarter method. The appropriate minimum quantity of material depends upon the maximum size of particles present, and is indicated in Table 2.2.1 Page.

- The specimen is placed on a tray and is allowed to dry, preferably overnight, in an oven maintained at 105-110 °C After drying to constant weight, the whole specimen is allowed to cool, and is weighted to an accuracy within 0.1% or less of its total mass (M_1).

FIG 2 . vibrator

4.4.3 Procedure

Take about 1000g of soil which is a mixture of silt, clay etc Arrange the sieve set in order of 4.75mm, 2.36mm, 1.18mm, 600µ, 300µ, 150µ, 75µ and a pan at the bottom..Place the sand in the top of the sieve and cover it with the lid and fix the set with the lid in the mechanicalshaker. Sieve it for 10 minutes and remove from the shaker. Weight the amount of soil retained in each sieve. Tabulate the weights retained and find the percentageeretained

TABLE 2 Sieve %

% Retained			Type Of Soil IS 1498 - 1970
4.75mm 10	425µ 50	75µ 180	Silty Clay

4.2 Properties Of Coir Fiber

Coir is a natural biodegradable material abundantly available in some parts of south and coastal regions of India. The abundant availability of natural fibre in India gives attention on the development of natural fibre composites primarily to explore value-added application avenues. Reinforcement with natural fibre in composites has recently gained attention due to low cost, easy availability, low density, acceptable specific properties, ease of separation, enhanced energy recovery, C02 neutrality, biodegradability and recyclable in nature.

IV. Physical and Mechanical Properties

1. Applications

Construction and maintenance of pavements in water- logged areas pose challenging problems to engineers. The defects in road sub-grades mainly arise due to poor compaction and consolidation. This is of major concern in road-works associated with submersible areas.Coir erosion fabrics provide firm support on slopes and unlike other natural fibre alternatives like cotton or jute, do not degrade until 5 years. They have the necessary strength and come in a number of forms such as matting, rolls and logs and are used for soil stabilization.Coconut fiber finds applications in slope stabilization in railway cutting and embankments, protection of water courses, reinforcement of temporary walls and rural unpaved roads, providing a sub base layer in road pavements, land reclamation and filtration in road drains, containment of soil and concrete as temporary seeding etc, highway cut and fillslopes, control of gully erosion and shallow mass waste.

V. General

The laboratory tests carried out first was on the natural soil which include Particle size distribution, Atterberg limits, Compaction, CBR and UCS. The geotechnical properties of the soil are determined in accordance with Indian Standard. Specimen for Unconfined compressive strength (UCS) and California bearing ratio (CBR) tests are prepared at the Optimum moisture contents (OMC) and Maximum dry densities (MDD).In the second phase of the study, four different percentages of Coir Fiber, 0.5%, 1%, 1.5% and 2% are mixed with soil in three different tests. For the above three different proportions, tests are carried out to observe the changes in the properties of soil. The following is the methodologies of each test.

1) **Proctor Compaction Test**
2) **Scope of the test**

Compaction of soil is the process by which the solid particles are packed more closely together, usually by mechanical means, thereby increasing the dry density of the soil. The dry density, which can be achieved, depends on the degree of compaction applied and on the amount of water present in the soil. For a given degree of compaction of a given cohesive soil there is an optimum moisture content at which the dry density obtained reaches a maximum value.

1. Proctor Compaction Test

1.1 Description

The apparatus consists of a metal cylinder 5.2cm in internal diameter and 40cm in effective height, clamped to the base. Oven dried soil, weighing 200g is mixed with water and compacted in the cylinder with the blows of 2.5kg rammer with a 5cm diameter circular face falling through a height of 35cm above the base. The number of blows to be used for compaction are decided by calibration tests either with respect to Proctor's compaction or field compaction test.The upper portion of the stem of the rammer is graduated in millimetres. The height of the compacted specimen may be determined from the reading on the graduated stem of the rammer. The volume of the compacted specimen is calculated from the known values of its height and cross section. Knowing the dry mass (i.e 200g) of the sample, the dry density is known. A number of such specimen are compacted at varying water contents, and a graph is plotted between dry density and water content.

FIG 3. Proctor Compaction Test

1.2 Procedure

Take approximately 2500g of given soil sample present passing through 4.75mm sieve and add about 4% of water content keep the soil in the airtight container Clean the mould and fix it to the base and take empty weight of the mould without collar Grease the mould attach the collar Divide the mix soil in the container into 3 equal parts and compact it in the mould by swing 25 blows to each layer Remove the collar cut the excess soil with the help of a straight edge remove the base plate clean the mould outside and weigh it Repeat the above procedure by varying the water content until the weight of the mould with soil gets reduced.

1.3 Graph

Plot the graph taking water content along X-axis and dry density Y-axis

2 Unconfined Compressive Test

2.1 Description

The unconfined compression test is a special case of triaxial compression test in which $\sigma_2 = \sigma_3 = 0$. The cell pressure in the triaxial pressure is also called as the confining pressure. Due to the absence of such confining pressure, the uniaxial test is called the unconfined compression test. The cylindrical specimen of soil is subjected to major principal stress ($_1$) till the specimen fails due to shearing along a critical plane of failure. In its simplest form, the apparatus consists of a small load frame fitted with a proving to measure the vertical stress applied to the soil specimen. The deformation of the sample is measured with the help of a special dial gauge. The ends of the cylindrical specimen are hollowed in the form of a cone. The cone seatings reduce the tendency of the specimen to become barrel shaped by reducing end restraints. During the test, load versus deformation readings are taken and a graph is plotted. When a brittle failure occurs, the proving ring indicates a definite maximum load which drops rapidly with the further increase of strain. In such a case, the load corresponding to 20% strain is arbitrarily taken as the failure load.

2.2 Specimen Preparation

Take about 2500g of given soil sample (sieved in 2.36mm sieve) and add desired quantity of water to soil sample and mix it thoroughly Split soil into 3 equal positions and compact it in a mould giving 25 blows per length of soil With help of sampling tube prepare sample by extruding them from mould with the help of soil extraction Extract sample from sampling tube by pushing them from the cutting edge side

2.3 Test Procedure

Place the prepared samples in a split mould and trim the end of the mould with help of knife Measure initial length and dia of the specimen. Put the specimen on bottom plate of loading dance adjust upper table to make contact with specimen set load dial. gauge and strain dial gauge to zero. Compress the specimen on the bottom plate until the cracks have definitely developed until a vertical deformation of 20% is reached. Take load dial gauge reading approximately at every 0.5mm deformation of specimen. Measure final length of specimen

3 Direct Shear Test

3.1 Scope

The direct shear test is used to measure shear strength, friction angle and cohesion of soils for stability analysis of foundation, slopes, and retaining walls. The test may take place under drained, undrained or consolidated-undrained conditions.

4 California Bearing Ratio Test

4.1 Scope of the Test

This method covers the laboratory determination of the California Bearing Ration (CBR) of a compacted or undisturbed sample of soil. The principle is to determine the relation between force and penetration when a cylindrical plunger with a standard cross-section area is made to penetrate the soil at a given rate. At certain values of penetration the ratio of the applied force to a standard force, expressed as a percentage, is defined as the California Bearing Ratio (CBR). The Californian Bearing Ratio test, or CBR-test, is an empirical test, which is used as an important criterion in pavement design. With this test, the bearing value of highway sub-bases and sub-grades, can be estimated.

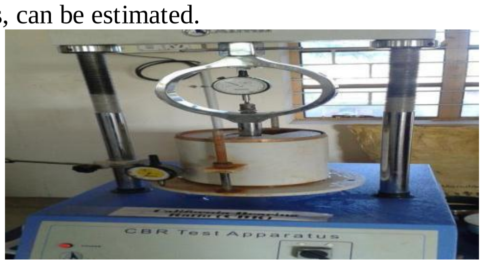


FIG 4. Californian Bearing Ratio test

VI. Results & Discussion

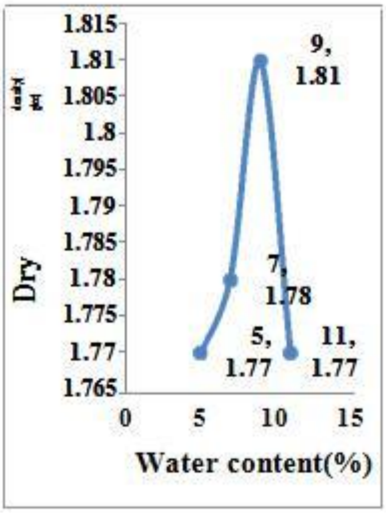
1. Proctor Compaction Test

Proctor Compaction Test is done to determine the optimum moisture content and maximum dry density. By conducting the test, the optimum water content is obtained at 9% of water content and the maximum dry density is 1.81g/cc. The values of dry density for the soil without fiber content is shown in table below.

Table 3. Compaction Test

Sl. No.	Water content (%)	Weight of mould + soil (w1) (g)	Weight of soil (w) (g)	Bulk density (γ) (g/cc)
1.	5	7870	2190	1.86
2.	7	7920	2240	1.90
3.	9	8005	2325	1.97
4.	11	7990	2310	1.96

Graph 1



2. CBR Test

CBR test is done for soaked specimens with various fiber proportions.

Sl. No	Lime Content (%)	Average CBR value (%)
1	0	12
2	0.5	14
3	1	17
4	1.5	21
5	2	25

The minimum CBR value of soil is 12 and the maximum CBR value is 25which show the increase in CBR value with increase in fiber content.

VII. Conclusion

The present study explained the performance of the coir fiber as a filler component in embankment material without chemical stabilizers like lime or gypsum. A detailed laboratory analysis on the consequences of the application of coir fiber with varying percentage stabiliser in order to observe the variation of various values is done. The proctor compaction test gives the optimum value of fiber 2% (Dr. M. T. Prathap Kumar and Jairaj ,2014) and its optimum water content as 9%. The results from the experiments shows that the strength of soil increases with increase in percentage of fiber. The compressive strength of soil is maximum at 2% of fiber with a value of 5.4 N/mm². The shear strength of the soil is tested by direct shear test and the maximum angle of friction is 29.9° at fiber content 2% of the volume of soil. The CBR value is maximum when 2% of fiber is added and the specimen is soaked for a period of 4days. The maximum CBR value obtained is 25. Thus the coir fiber reinforced soil can be used in embankments, highway, etc.

VIII. Recommendations

From this test experiment various future scope of work can be obtained:
The similar natures of investigation are also recommended for higher percentage of coir fiber.

1. The similar natures of investigation are also recommended for other organic fibers like jute, bamboo, sisal etc.
2. The similar natures of investigations are also recommended for cohesion less soils inreplacement of silty clay soil.

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