STABILIZATION OF CLAY SOIL USING NATURAL COIR FIBER

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ABSTRACT

Soil is the major and most commonly used material in the field of Civil Engineering. Where ever it is used construction, foundation, bricks, pavements it should provide considerable strength for the stability of the structure. There are various types of soil present in the earth depending upon the material property, size, texture, various properties. In that clay soil is one of its type a fine-grained natural rock or soil material that combines one or more clay minerals with traces of metal oxides and organic matter. Depending upon the material composition clay also posses various properties. It is slow to drain, quickly to harden, and difficult to use for anything because of its finer particle size. Black cotton soil is a kind of expansive soil in which it expands in its volume in wet condition and shrinks in dry condition. Some situations construction on the clay soil is not avoidable one therefore soil stabilization is one of the most commonly used methods to increase the engineering properties of the soil, as a result of soil stabilization, the bearing capacity of the foundation of the structure is increased and its strength, water tightness, resistance to washout. The basic methods of stabilization are cementation, bituminization, silicification, resinification, methods using electrochemical or thermal action, and artificial freezing. These methods can cause some effects on the environment. In the context of sustainable development the natural environment, the use of natural Fibres such as coir in geotechnical applications is desirable. Reinforcing the soil with coir Fibres/coir geo-textiles is a cost effective solution to the ground/soil improvement problems. This experimental study deals with the use of coconut Fibre for soil stability. The study includes the properties of coir Fibre and clay and experimental workouts such as tri-axial test, Stress state during a tri-axial test, California bearing ratio, unconfined compression test, direct shear test.

Keywords: Experimental Study, Stabilization, Clay Soil, Coir Fibre

1. INTRODUCTION

Soil is an accumulation or deposit of earth material, derived naturally from disintegration of rocks or decay of vegetation, that can be excavated readily with power equipment in the field or disintegrated by gentle mechanical means in the laboratory. The supporting soil beneath pavement and its special under courses is called sub grade. Undisturbed soil beneath the pavement is called natural sub grade. Compacted sub grade is the soil compacted by controlled movement of heavy compactors. Sub grade soils are an essential component of pavement structures, and inadequate sub grade performance is the cause of many premature pavement failures. Clay sub-grades in particular may provide inadequate support, particularly when saturated. Soils with significant plasticity may also shrink and swell substantially with changes in moisture conditions. These changes in volume can cause the pavement to shift or heave with changes in moisture content, and may cause a reduction in the density and strength of the sub grade, accelerating pavement deterioration. Pavement design is based on the premise that minimum specified structural quality will be achieved for each layer of material in the pavement system. Each layer must resist shearing, avoid excessive deflections that cause fatigue cracking within the layer or in overlying layers, and prevent excessive permanent deformation through densification.

As the quality of a soil layer is increased, the ability of that layer to distribute the load over a greater area is generally increased so that a reduction in the required thickness of the soil and surface layers may be permitted. The most common improvements achieved through stabilization include better soil gradation, reduction of plasticity index or swelling potential, and increases in durability and strength. In wet weather, stabilization may also be used to provide a working platform for construction operations. These types of soil quality improvement are referred to as soil modification or soil stabilization. The soil must first be classified as either a sub grade category or base category material. In order to be classified as a base material the following criteria must be met:

- A maximum of 25 percent of the soil mass passes the No. 200 sieve (0.074 mm or 0.003 in.),
- Not more than 40 percent of the soil mass passes the No. 40 sieve (0.42 mm or 0.0165 in.),
- A maximum plasticity index of 12 percent, and (4) a maximum liquid limit of 40 percent.

Otherwise, it is classified as a sub grade material for stabilization purposes. The definition of modification and stabilization can be ambiguous. In this document modification refers soil improvement that occurs in the short term, during or shortly after mixing (within hours). This modification reduces the plasticity of the soil (improves the consistency) to the desired level and improves short-term strength to the desired level (short-term is defined as strength derived immediately within about 7-days of after compaction). Even if no significant pozzolanic or cementious reaction occurs, the textural changes that accompany consistency improvements normally result in measurable strength improvement. Stabilization occurs when a significant, longer-term reaction takes place. This longer-term reaction can be due to hydration of calcium-silicates and/or calcium aluminates in Portland cement or class C fly ash or due to pozzolanic reactivity between free lime and soil pozzolans or added pozzolans. A strength increase of 50 psi (350 kPa) or greater (of the stabilized soil strength compared to the untreated soil strength under the same conditions of compaction and cure) is a reasonable criterion for stabilization.

1.1 Coir Fibre

Soil being the cheapest and readily available construction material, has been Popular with the civil Engineers, even though it being poor properties. It has been the constant endeavor of research workers to put forth innovative ideas to improve its mechanical properties to suit the requirements of engineering students. The construction of road imposes a heavy pressure on limited resources like suitable earth, stone aggregates binders etc. For sustainable development use of locally available materials, waste material should be encouraged in order to save the natural resources for future generation. There are many types of waste material found in India like coal ash, stone quarry, plastics, recycled aggregate, geo-synthetic materials and polythene bags etc but coconut coir Fibre is used in this research paper. In future many roads and highways will be constructed near the Chandigarh. Coconut coir Fibre may be utilized in these highways projects. Coir or coconut Fibre belongs to the group of hard structural Fibres. It is an important commercial product obtained from the husk of coconut. The coir Fibre is elastic enough to twist without breaking and it holds a curl as though permanently waved. Shorter mattress Fibres are separated from the long bristle Fibres which are in turn a waste in the coir Fibre industry. So this coir Fibre waste can be used in stabilization of soil and thus it can be effectively disposed off. The inclusion of Fibres had a significant influence on the engineering behavior of soil-coir mixtures. The addition of randomly distributed polypropylene Fibres resulted in substantially reducing the consolidation settlement of the clay soil. Length of Fibres has an insignificant effect on this soil characteristic, whereas Fibre contents proved more influential and effective. Addition of Fibre resulted in decrease in plasticity and increase in hydraulic conductivity. As a result there has been a growing interest in soil/Fibre reinforcement. The work has been done on strength deformation behavior of Fibre reinforced soil and it has been established beyond doubt that addition of Fibre in soil improves the overall engineering performance of soil. Fibre mixed with soil has been used in many countries in the recent past and further research is in progress for many hidden aspects of it. Fibre mixed with soil is effective in all types of soils (i.e. sand, silt and clay). The main advantage of coir material is this it is locally available and is very cheap. This is biodegradable and hence do not create disposal problem in environment. This research presents the influence of coir Fibre on the UCS and CBR value of soil from Industrial area, panchkula, India. The number of unsoaked and soaked CBR value and UCS tests have been conducted on soil and soil mixed with varying amount of coir Fibre (0.25, 0.50, 0.75, and 1.0%). The UCS and CBR values of soil-coir have been compared with that of unmixed soil. Traditionally, coir has been processed into a range of products such as yarns for the production of floor coverings, mats and matting, cordage and nets, bristle Fibres for brooms and brushes, and for use with domestic mattress and upholstery industries. These markets have been dwindling in recent years due to strong competition from synthetic products. However, there is a firm trend in the industrial countries towards the production and use of more environmentally benign products and systems, which may help to mitigate the adverse ecological affects of current production methods. The effects of chemical industries, atmospheric degradation, global warming, fast-declining natural resource base, deforestation, waste production, pollution and similar global issues have increased the demand for environmentally benign products.

2. METHODOLOGY

Methodology adopted in this study shown in Figure.1

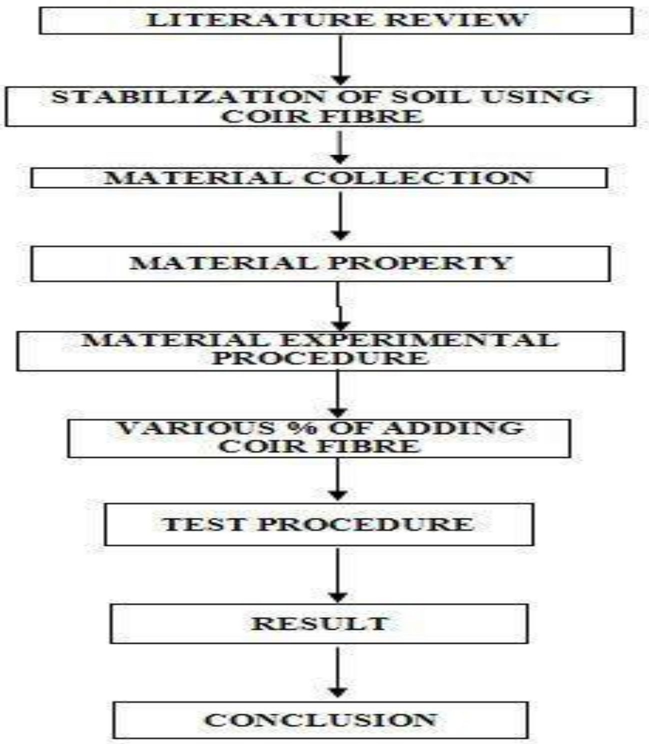

Figure.1. Methodology

3. SOIL STABILIZATION

3.1 Mechanisms Of Stabilization

The stabilization mechanism may vary widely from the formation of new compounds binding the finer soil particles to coating particle surfaces by the additive to limit the moisture sensitivity. Therefore, a basic understanding of the stabilization mechanisms involved with each additive is required before selecting an effective stabilizer suited for a specific application. Chemical stabilization involves mixing or injecting the soil with chemically active compounds such as Portland cement, lime, fly ash, calcium or sodium chloride or with viscoelastic materials such as bitumen. Chemical stabilizers can be broadly divided in to three groups: Traditional stabilizers such as hydrated lime, Portland cement and Fly ash; Non-traditional stabilizers comprised of sulfonated oils, ammonium chloride, enzymes, polymers, and potassium compounds; and By-product stabilizers which include cement kiln dust, lime kiln dust etc. Among these, the most widely used chemical additives are lime, Portland cement and fly ash. Although stabilization with fly ash may be more economical when compared to the other two, the composition of fly ash can be highly variable. The mechanisms of stabilization of the traditional stabilizers are detailed below.

3.1.1 Traditional Stabilizers

Traditional stabilizers generally rely on pozzolanic reactions and cation exchange to modify and/or stabilize. Among all traditional stabilizers, lime probably is the most routinely used. Lime is prepared by decomposing limestone at elevated temperatures. Lime-soil reactions are complex and primarily involve a two step process. The primary reaction involves cation exchange and flocculation/ agglomeration that bring about rapid textural and plasticity changes. The altered clay structure, as a result of flocculation of clay particles due to cation exchange and short-term pozzolanic reactions, results in larger particle agglomerates and more friable and workable soils. Although pozzolanic reaction processes are slow, some amount of pozzolanic strength gain may occur during the primary reactions, cation exchange and flocculation/agglomeration. Extent of this strength gain may vary with soils depending on differences in their mineralogical composition.

3.1.2 By-Product Stabilizers

Like traditional stabilizers, pozzolanic reactions and cation exchange are the primary stabilization mechanisms for many of the by-product stabilizers. Lime kiln dust (LKD) and cement kiln dust (CKD) are by-products of the production of lime and Portland cement, respectively. Lime kiln dust (LKD) normally contains between about 30 to 40 percent lime. The lime may be free lime or combined with pozzolans in the kiln. The source of these pozzolans is most likely the fuel used to provide the energy source. LKDs may be somewhat pozzolanically reactive because of the

presence of pozzolans or they may be altogether non reactive due to the absence of pozzolans or the low quality of the pozzolans contained in the LKD. Cement kiln dust (CKD) is the byproduct of the production of Portland cement. The fines captured in the exhaust gases of the production of Portland cement are more likely (than LKD) to contain reactive pozzolans and therefore, to support some level of pozzolanic reactivity. CKD generally contains between about 30 and 40 percent CaO and about 20 to 25 percent pozzolanic material.

3.1.3 Non Traditional Stabilizers

The mechanism of stabilization for non-traditional stabilizers varies greatly among the stabilizers. Asphalt may or may not be grouped as a traditional stabilizer depending on perspective. Asphalt is not a “chemical” stabilizer in the sense that it does not react chemically with the soil to produce a product that alters surface chemistry of the soil particles or that binds particles together. Instead asphalt waterproofs aggregate and soil particles by coating them and developing an adhesive bond among the particles and the asphalt binder.

3.2 Soil Classification

Soil is a broad term used in engineering applications which includes all deposits of loose material on the earth's crust that are created by weathering and erosion of underlying rocks. Although weathering occurs on a geologic scale, the process is continuous and keeps the soil in constant transition. The physical, chemical, and biological processes that form soils vary widely with time, location and environmental conditions and result in a wide range of soil properties. Physical weathering occurs due to temperature changes, erosion, alternate freezing and thawing and due to plant and animal activities causing disintegration of underlying rock strata whereas chemical weathering decomposes rock minerals by oxidation, reduction, hydrolysis, chelation, and carbonation. These weathering processes, individually or in combination.

3.3 Components Of Stabilization

Soil stabilization involves the use of stabilizing agents (binder materials) in weak soils to improve its geotechnical properties such as compressibility, strength, permeability and durability. The components of stabilization technology include soils and or soil minerals and stabilizing agent or binders (cementious materials).

3.3.1 Soils

Most of stabilization has to be undertaken in soft soils (silty, clayey peat or organic soils) in order to achieve desirable engineering properties. According to Sherwood (1993) fine-grained granular materials are the easiest to stabilize due to their large surface area in relation to their particle diameter. A clay soil compared to others has a large surface area due to flat and elongated particle shapes. On the other hand, silty materials can be sensitive to small change in moisture and, therefore, may prove difficult during stabilization .Peat soils and organic soils are rich in water content of up to about 2000%, high porosity and high organic content. The consistency of peat soil can vary from muddy to fibrous, and in most cases, the deposit is shallow, but in worst cases, it can extend to several meters below the surface. Organic soils have high exchange capacity; it can hinder the hydration process by retaining the calcium ions liberated during the hydration of calcium silicate and calcium aluminate in the cement to satisfy the exchange capacity.

3.3.2 Stabilizing Agents

These are hydraulic (primary binders) or non-hydraulic (secondary binders) materials that when in contact with water or in the presence of pozzolanic minerals reacts with water to form cementious composite materials. The commonly used binders are:

- Cement
- Lime
- Fly Ash
- Blast Furnace Slag

4. SOIL STABILIZATION METHODS

Soil stabilization is a method of improving soil properties by blending and mixing other materials. Following are the various soil stabilization methods and materials:

4.1 In–Situ Stabilization

The method involves on site soil improvement by applying stabilizing agent without removing the bulk soil. This technology offer benefit of improving soils for deep foundations, shallow foundations and contaminated sites. Planning of the design mix involves the selection and assessment of engineering properties of stabilized soil and improved ground. The purpose is to determine the dimensions of improved ground on the basis of appropriate stability and

settlement analyses to satisfy the functional requirements of the supported structure (Keller Inc.). The technology can be accomplished by injection into soils a cementious material such cement and lime in dry or wet forms. The choice to either use dry or wet deep mixing methods depend among other things; the in-situ soil conditions, in situ moisture contents, effectiveness of binders to be used, and the nature of construction to be founded. Depending on the depth of treatment, the in situ stabilization may be regarded as either deep mixing method or mass stabilization.

4.2 Deep Mixing Method

The deep mixing method involves the stabilization of soils at large depth. It is an in situ ground modification technology in which a wet or dry binder is injected into the ground and blended with in situ soft soils (clay, peat or organic soils) by mechanical or rotary mixing Tool. Depending on applications, the following patterns may be produced; single patterns, block patterns, panel pattern or stabilized grid pattern. Note that, the aim is to produce the stabilized soil mass which may interact with natural soil and not, to produce too stiffly stabilized soil mass like a rigid pile which may independently carry out the design load. The increased strength and stiffness of stabilized soil should not, therefore, prevent an effective interaction and load distribution between the stabilized soil and natural soil.

4.3 Wet Mixing

Applications of wet deep mixing involve binder turned into slurry form, which is then injected into the soil through the nozzles located at the end of the soil auger. The mixing tool comprise of drilling rod, transverse beams and a drill end with head. There are some modifications to suit the need and applications. For instance, the Trench cutting Re-mixing deep method (TRD) developed by circa Japan, in 1993 provides an effective tool for construction of continuous cutoff wall without the need for open trench. The method uses a crawler-mounted, chainsaw-like mixing tool to blend in-situ soil with cementious binder to create the soil-cement wall. It further consists of a fixed post on which cutting, scratching teeth ride on a rotating chain and injection ports deliver grout into treatment zone.

4.4 Dry Mixing

Dry mixing (DM) method is clean, quiet with very low vibration and produces no spoil for disposal (Hayward Baker Inc). It has for many years extensively used in Northern Europe and Japan. The method involves the use of dry binders injected into the soil and thoroughly mixed with moist soil. The soil is premixed using specialized tool during downward penetration, until it reaches the desired depth. During withdrawal of the mixing tool, dry binder are then injected and mixed with premixed soil leaving behind a moist soil mix column. In Scandinavians countries and Sweden in particular, this method is referred to as Lime Cement Column (LCC), whereas, in Italy, the method is termed as Trevimix and in Japan, the same technology is called dry jet mixing (DJM).

4.5 Soil Stabilization With Cement

The soil stabilized with cement is known as soil cement. The cementing action is believed to be the result of chemical reactions of cement with siliceous soil during hydration reaction. The important factors affecting the soil-cement are nature of soil content, conditions of mixing, compaction, curing and admixtures used.

4.5.1 Soil Stabilization Using Lime

Slaked lime is very effective in treating heavy plastic clayey soils. Lime may be used alone or in combination with cement, bitumen or fly ash. Sandy soils can also be stabilized with these combinations. Lime has been mainly used for stabilizing the road bases and the subgrade. Lime changes the nature of the adsorbed layer and provides pozzolanic action. Plasticity index of highly plastic soils are reduced by the addition of lime with soil. There is an increase in the optimum water content and a decrease in the maximum compacted density, strength and durability of soil increases. Normally 2 to 8% of lime may be required for coarse grained soils and 5 to 8% of lime may be required for plastic soils. The amount of fly ash as admixture may vary from 8 to 20% of the weight of the soil.

4.5.2 Soil Stabilization With Bitumen

Asphalts and tars are bituminous materials which are used for stabilization of soil, generally for pavement construction. Bituminous materials when added to a soil, it imparts both cohesion and reduced water absorption. Depending upon the above actions and the nature of soils, bitumen stabilization is classified in following four types:

- Sand bitumen stabilization
- Soil Bitumen stabilization
- Water proofed mechanical stabilization, and
- Oiled earth.

4.5.3 Chemical Stabilization Of Soil

Calcium chloride being hygroscopic and deliquescent is used as a water retentive additive in mechanically stabilized soil bases and surfacing. The vapor pressure gets lowered, surface tension increases and rate of evaporation decreases. The freezing point of pure water gets lowered and it results in prevention or reduction of frost heave.

4.5.4 Electrical Stabilization Of Clayey Soils

Electrical stabilization of clayey soils is done by method known as electro-osmosis. This is an expensive method of soil stabilization and is mainly used for drainage of cohesive soils.

4.5.5 Soil Stabilization By Grouting

In this method, stabilizers are introduced by injection into the soil. This method is not useful for clayey soils because of their low permeability. This is a costly method for soil stabilization. This method is suitable for stabilizing buried zones of relatively limited extent. The grouting techniques can be classified as following:

5. MATERIAL COLLECTION

5.1 Clay Soil

Clay is a fine-grained natural rock or soil material that combines one or more clay minerals with traces of metal oxides and organic matter. Clays are plastic due to their water content and become hard, brittle and non–plastic upon drying or firing.[1] Geologic clay deposits are mostly composed of phyllosilicate minerals containing variable amounts of water trapped in the mineral structure. Depending on the content of the soil, clay can appear in various colors, from white to dull gray or brown to a deep orange-red.

5.2 Soil Properties

5.2 .1 Soil Structure

Soil is comprised of three-dimensional arrangements of solid particles and pores. Soil structure is determined by the distribution and the size of these soil aggregates and pore spaces. Soil structure is influenced by its physical, chemical and biological characteristics.

5.2.2 Texture

Clay soil has a distinctive texture. When dry, it holds its shape, and does not crumble like sand. When it is wet, it can be sculpted and molded into different shapes. To test the amount of clay in your soil, roll a moist chunk into a 1-inch ball and press it flat between your thumbs. If it falls apart, then you probably do not have much clay content. If it stays together and grows over an inch long before it breaks, then you have a lot of clay content. Most soils will fall somewhere in between, stretching to an inch or so before falling apart. Damp clay soil is very sticky.

For all mineral soils, the proportion of sand, silt, and clay always adds up to 100 percent. These percentages are grouped into soil texture "classes", which have been organized into a "textural triangle".

5.2.3 Water holding Capacity

Clay soil can hold a lot of water. Some of the mineral particles swell up when they get wet. This can "choke" tender roots. It also results in a very compacted soil when teeny tiny particles are pressed into one another and then swell up again. If you have soaked your garden thoroughly for two hours or more, and the soil is still dry 2 to 3 inches from the surface, then you probably have a lot of clay in the top layers.

5.2.4 Acidity And Alkalinity

Clay soil tends to be very alkaline. Some plants and insects thrive in an alkaline environment. Others prefer an acidic environment. Most creatures, however, prefer neutrality. The ideal garden soil is fairly neutral at 3-8 on the pH scale. Adding peat moss, composted oak leaves, elemental sulfur, watering with vinegar, cottonseed meal, ammonium phosphate and gypsum can all acidify the soil.

5.2.5 Soil Consistence

Soil consistence refers to the ease with which an individual pad can be crushed by the fingers. Soil consistence, and its description, depends on soil moisture content. Terms commonly used to describe consistence are:

Moist soil:

- loose – non coherent when dry or moist; does not hold together in a mass
- friable – when moist, crushed easily under gentle pressure between thumb and forefinger and can be pressed together into a lump
- firm – when moist crushed under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable

Wet soil:

- plastic – when wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger
- sticky – when wet, adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material.

Dry Soil:

- soft – when dry, breaks into powder or individual grains under very slight pressure
- hard – when dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

5.2.6 Bulk Density

Bulk density is the proportion of the weight of a soil relative to its volume. It is expressed as a unit of weight per volume, and is commonly measured in units of grams per cubic centimeters (g/cc).Bulk density is an indicator of the amount of pore space available within individual soil horizons, as it is inversely proportional to pore space:

Pore space = 1 – bulk density/particle density

For example, at a bulk density of 1.60 g/cc, pore space equals 0.40 or 40%. At a bulk density of 1.06 g/cc, pore space equals 0.60 or 60%.

5.3 Coir Fibres

Coconut coir is a natural Fibre extracted from the husk of coconut. It is the fibrous material found between the hard, internal shell and outer coat of a coconut. The main advantage of using coconut coir in improving the strength of soil sub grade is they are cheap, locally available and eco friendly. In this study the coconut coir is extracted mainly from green nut.(Table.1)

S.No	Description	Value
1	Diameter	0.5mm
2	Length	3cm to 5 cm
3	Specific gravity	1.3

Table 1 Properties of coconut coir

Coir or coconut Fibre belongs to the group of hard structural Fibres. The coir Fibre is elastic enough to twist without breaking and it holds a curl as though permanently waved. The inclusion of Fibres had a significant influence on the engineering behavior of soil-coir mixtures. (Figure.2)

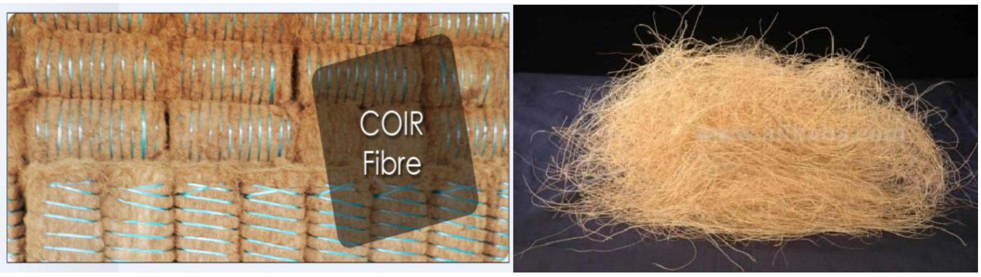

Figure.2 Coir Fibre

The addition of randomly distributed polypropylene Fibres resulted in substantially reducing the consolidation settlement of the clay soil. Length of Fibres has an insignificant effect on this soil characteristic, whereas Fibre contents proved more influential and effective. Addition of Fibre resulted in decrease in plasticity and increase in hydraulic conductivity. As a result there has been a growing interest in soil/Fibre reinforcement. The work has been done on strength deformation behavior of Fibre reinforced soil and it has been established beyond doubt that addition of Fibre in soil improves the overall engineering performance of soil. Fibre mixed with soil has been used in many countries in the recent past and further research is in progress for many hidden aspects of it.

5.4 Properties Of Coir Fibre

5.4.1 Coir Pith

As a by-product of coir fibre extraction large quantities of pith are obtained, which have been accumulating at production sites over the years. The extraction of 1 kg of fibre generates more than 2 kg of coir pith. Recently, however, the product has gained commercial interest as a substitute for peat moss in horticultural substrate cultivation. Low susceptibility to biodegradation and a highly porous structure enables coir pith to absorb large volumes of water (more than 50 per cent by weight), which makes it highly suitable in a potting mixture. For horticultural use, the product has to meet specific chemical and biological standards of pH, electrical conductivity and elemental composition. Repression of sodium and potassium from the cation complex of the coir may be desirable for many sensitive horticultural products. Technical information to describe microbial contamination and product safety is another concern for users.

5.4.2 Quality

The different fibre extraction processes yield different but also varying qualities of fibres generally 56-65 per cent long fibres of over150 mm (up to 350 mm staple length) and 5-8 per cent short fibres of under 50 mm. The fibre fineness varies between 50 and 300 µm. The fibres are composed of individual fibre cells of about 1 mm length and 5-8 µm diameter. The tensile strength of coir is relatively low when compared to sisal or abaca fibres, but it is less impaired by immersion in water. Coir fibre has the advantage of stretching beyond its elastic limit without rupturing, as well as having the power to take up a permanent stretch. Its resistance to microbial degradation and salt water is unique.

Length in inches	6-8
Density (g/cc)	1.40
Tenacity(g/Tex)	10.0
Breaking Elongation%	30%
Diameter in mm	0.1 to 0.5
Rigidity of Modulus	1.8924dyne/cm^2

Table.2 Physical properties of coir fibre

Lignin	45.84%
Cellulose	43.44%
Hemi –Cellulose	0.25%
Pectin's and related Compound	3.0%
Water soluble	5.25%
Ash	2.22%

Table 3 Chemical properties of coir fibre

The fibre fineness varies between 50 and 300 µm. The fibres are composed of individual fibre cells of about 1 mm length and 5-8 µm diameter. The tensile strength of coir is relatively low when compared to sisal or abaca fibres, but it is less impaired by immersion in water. Coir fibre has the advantage of stretching beyond its elastic limit without rupturing, as well as having the power to take up a permanent stretch. Its resistance to microbial degradation and salt water is unique.(Table.2). The chemical composition of coir and other plant fibres is given in Table, which shows that brown coir fibres contain relatively low amounts of cellulose (35 per cent) but have high lignin content (32 per cent). This exceptionally high lignin content implies that the available dyeing and bleaching techniques for textile fibres cannot simply be transferred to coir.(Table.3)

6. TEST PROCEDURE

6.1 Consolidation Test

Consolidation is a process by which soils decrease in volume. According to Karl von Terzaghi "consolidation is any process which involves a decrease in water content of saturated soil without replacement of water by air." In general it is the process in which reduction in volume takes place by expulsion of water under long term static loads. It occurs when stress is applied to a soil that causes the soil particles to pack together more tightly, therefore reducing its bulk volume. When this occurs in a soil that is saturated with water, water will be squeezed out of the soil. The magnitude of consolidation can be predicted by many different methods. In the Classical Method, developed by Terzaghi, soils are tested with an oedometer test to determine their compression index. This can be used to predict the amount of consolidation.

When stress is removed from a consolidated soil, the soil will rebound, regaining some of the volume it had lost in the consolidation process. If the stress is reapplied, the soil will consolidate again along a recompression curve, defined by the recompression index. The soil which had its load removed is considered to be over consolidated. This is the case for soils which have previously had glaciers on them. The highest stress that it has been subjected to is termed the pre consolidation stress. The over consolidation ratio or OCR is defined as the highest stress experienced divided by the current stress. A soil which is currently experiencing its highest stress is said to be normally consolidated and to have

an OCR of one. A soil could be considered under consolidated immediately after a new load is applied but before the excess pore water pressure has had time to dissipate.

6.2 Permeability Test

The permeability test is a measure of the rate of the flow of water through soil. In this test, water is forced by a known constant pressure through a soil specimen of known dimensions and the rate of flow is determined. This test is used primarily to determine the suitability of sands and gravels for drainage purposes, and is made only on remolded samples. The test is limited to materials which have a coefficient of permeability of approximately 300 mm/day or greater. The “Constant Head” type of test is used on samples that represent materials to be used as backfill for abutments, as permeable material for under drains, as sand drains, as sand blanket for sand drain areas, and similar materials.

6.3 Direct Shear Test

A direct shear test is a laboratory or field test used by geotechnical engineers to measure the shear strength properties of soil or rock material, or of discontinuities in soil or rock masses. A detailed description of the laboratory testing equipment and procedure can be also found on geotechdata.info direct shear test page; and of the field test equipment and procedure on geotechdata.info (field) vane shear test.

6.4 Unconfined Compression 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. The method is used primarily for saturated, cohesive soils recovered from thin-walled sampling tubes.

7. TESTING RESULT

7.1 Particle Size Distribution Analysis

Particle size distribution curves of clay. It is revealed from the figure that clay is uniformly graded in nature i.e. they are not having good representation of all particle sizes having larger range of finer particles while the sand is poorly graded in nature (Table.4).

S.NO	IS SIEVE	WEIGHT RETAINED (GM)	% RETAINED	COMMULATIVE RETAINED	% FINER (N)
1	100mm	-	-	-	100
2	63mm	4	0.4	0.4	96.4
3	20mm	55	5.5	5.9	94.1
4	10mm	36	3.6	9.5	90.5
5	4.75mm	47	4.7	14.2	85.8
6	1mm	85	8.5	22.7	77.3
7	600micron	132	13.2	35.9	64.1
8	pan	106	10.6	46.5	53.5

Table 4 Particle Size Distribution Analysis

7.1 Permeability Test

Table. 5 shows the Permeability Test Results

% OF ESP	INITIAL HEAD (H_1)	FINAL HEAD (H_2)	TIME COEFFICIENT OF PERMEABILITY	PERMEABILITY
NORMAL SOIL	72	58	5	0.2199
0.25 % OF COIR	78	58	5	0.3017
0.50 % OF COIR	83	48	5	0.5570
0.75 % OF COIR	88	52	5	0.5350
1.0 % OF COIR	94	82	5	0.1390

Table. 5 Permeability Test Results

NORMAL LOAD		PROVING RING READING	SHEAR FORCE	SHEAR STRESS
Normal soil	0.5	57	14.70	0.408
	1.0	108	27.83	0.773
0.25% of coir	0.5	73	18.75	0.512
	1.0	132	34.02	0.942
0.50% of coir	0.5	85	21.90	0.608
	1.0	148	38.14	1.059
0.75% of coir	0.5	63	16.23	0.45
	1.0	115	29.64	0.823
1.0% of coir	0.5	52	13.40	0.372
	1.0	102	26.28	0.730

Table. 6 Direct Shear Test Results

7.2 Direct Shear Test

Table 6 shows the Direct Shear Test Result

7.3 Consolidation Test

Table. 7 shows the Consolidation Test Result On Soil

% OF COIR	COEFFICIENT OF CONSOLIDATION
NORMAL SOIL	0.032
0.25% OF COIR	0.115
0.5% OF COIR	0.213
0.75% OF COIR	0.174
1.0% OF COIR	0.105

Table 7 Consolidation Test Result On Soil

7.4 Standard Proctor Compaction Tests

Standard proctor's compaction tests using light compaction have been carried out in accordance with relevant IS standard, to determine the maximum dry density (MDD)and optimum moisture content (OMC) for the selected soil. Results shown in Figure. 3, 4, 5, 6 and 7.

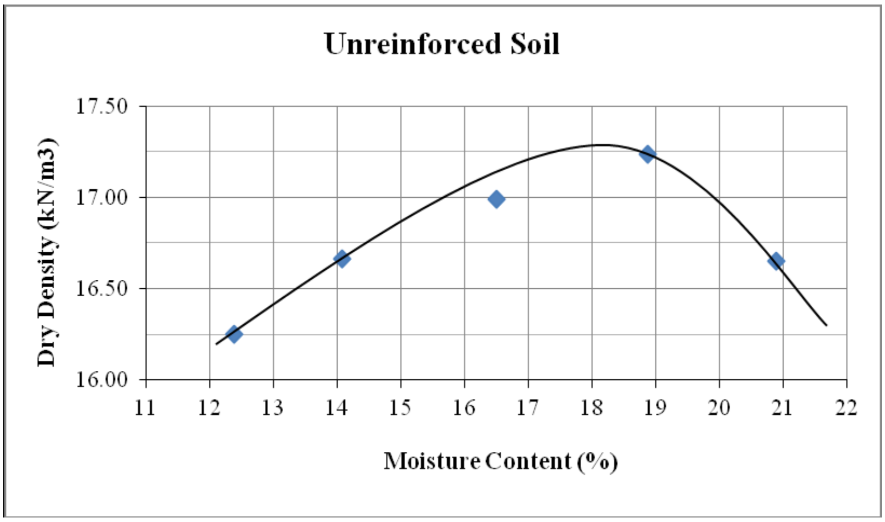

Figure.3 Maximum Dry Density for Unreinforced Soil

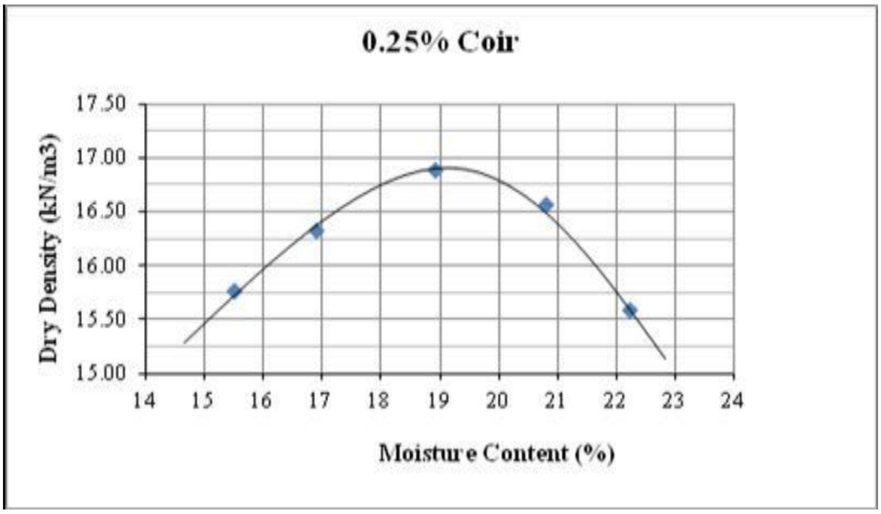

Figure.4 Maximum DryDensityfor Reinforced Soilwith 0.25% Coir

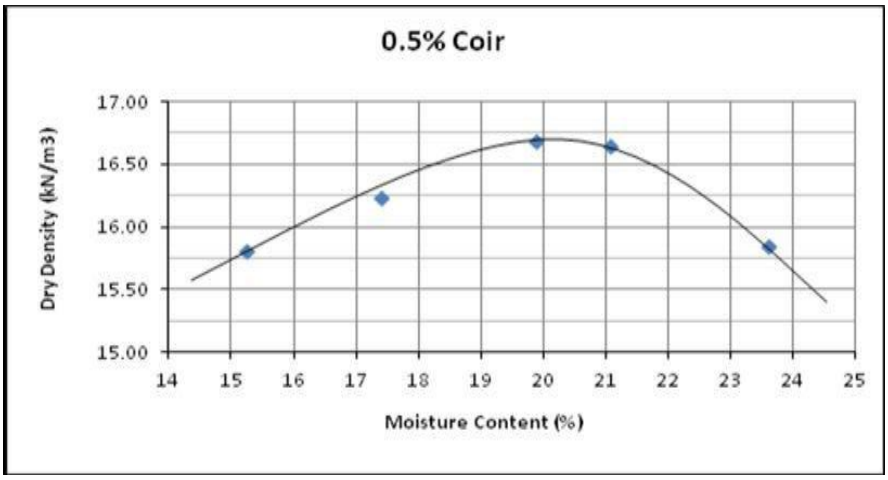

Figure.5 Maximum Dry Density for Reinforced Soil with 0.5%Coir

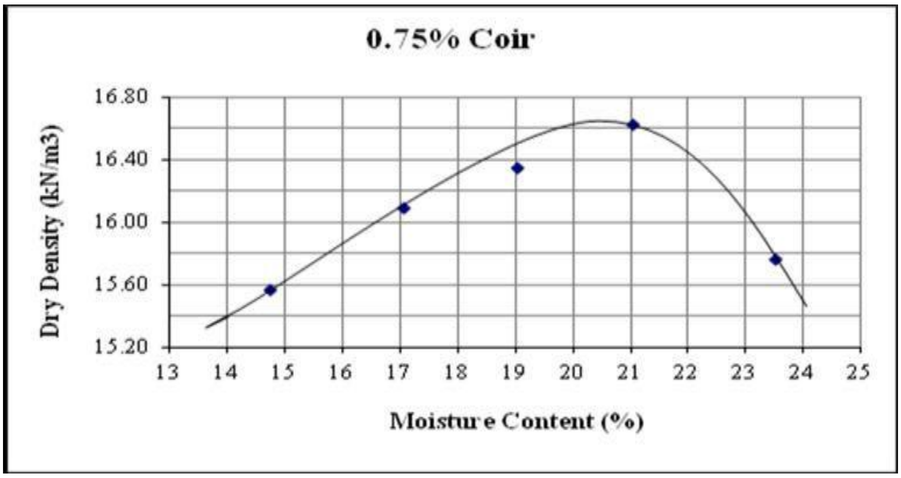

Figure. 6 Maximum Dry Density for Reinforced Soil with 0.75% Coir

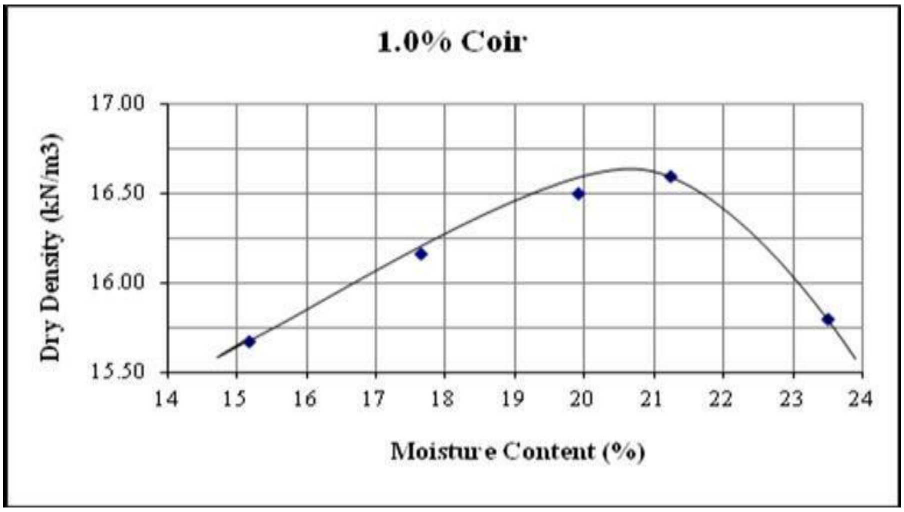

Figure.7 Maximum Dry Density for Reinforced Soil with 1.0%Coir

	Strain dial (0.02mm)	Axial Strain (ΔL/Lo) %	Corrected area (cm^2)	Load dial (0.01mm)	Axial load(N)	Unit pressure (KN/m^2)
Normal soil	0.4	0.5	10.55	0.3	2.32	3.25
	0.8	1.0	10.61	0.8	12.70	11.50
Soil+0.25%	0.4	0.5	10.55	0.5	4.38	4.15
	0.8	1.0	10.61	2.0	17.50	16.50
Soil+0.50%	0.4	0.5	10.55	0.2	1.75	1.66
	0.8	1.0	10.61	0.4	3.50	3.30
Soil+0.75%	0.4	1.3	10.63	0.0	0.00	0.00
	0.8	2.5	10.76	0.2	1.75	1.63
Soil+1.0%	0.4	0.5	10.55	0.3	3.35	1.25
	0.8	1.0	10.61	0.8	21.45	13.75

Table.8 Unconfined Compression Test Results

7.1 Unconfined Compression

Unconfined Compression Test Results given in Table.8

1. CONCLUSION

The present study has shown quite encouraging results and following important conclusions can be drawn from the study:

- Coir Fibre is a waste material which could be utilized in a stabilization of clay soil.
- The strength of soil-coir mix increases with increasing the percentage of coir Fibre.
- CBR and UCS values of soil-coir Fibre mix increases with increasing percentage of Fibre.
- Maximum improvement in U.C.S. and C.B.R. values are observed when 0.5% of coir is mixed with the soil.
- It is concluded that proportion of 0.5% coir Fibre in a soil is optimum percentage of materials having maximum soaked CBR value. Hence, this proportion may be economically used in stabilization of clay soil.

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