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Experimental Investigation on Comparison of Soil Stabilization by Using Waste Plastic and Coirfibre

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Abstract – Soil stabilization is a process which improves the physical properties of soil, such as increasing shear strength, bearing capacity etc. which can be done by use of controlled compaction .This new technique of soil stabilization can be effectively used to meet the challenges of society, to reduce the quantities of waste, producing useful material from non-useful waste materials.Soil stabilization provides a capping layer thereby increases the CBR of the soil to the desired level. The Waste Plastic and coir fibre are used here as stabilization additives.Plastic such as waste plastic bottles is used to as a soil stabilizer to improving the safe bearing capacity of soil. Plastic strips obtained from waste plastic were mixed randomly with the soil is taken as 0.25%, 0.50%, 0.75% and 1% This is due to the change in brittle behaviour of the soil to ductile behavior. In this study, the stabilizing effect of Coconut coir Fibre (Natural Fibre) on soil properties has been Experimental studied. Keeping in this view an experimental study is conducted on locally available soil mixed with varying percentage of Coconut coir fibre. Use of Coconut coir Fibre for improving soil property is advantageous because they are cheap, locally available and eco-friendly. The percentage of Coconut coir fibre by dry weight of soil is taken as 0.25%, 0.50%, 0.75% and 1%. Tests result indicates that CBR value of soil increases with the increase in Coconut coir fibre content CBR value increases from 8.1 % to 13.2 % of soil mixed with 1% Coconut coir fibre. Adding of coconut coir fibre results in less thickness of pavement due to increase in CBR of mix and reduce the cost of construction and hence economy of the construction will be achieved. This is because of composite effect of Coconut coir fibre (Natural Fibre) changes the brittle behaviour of the soil to ductile behaviour. Soil stabilization has become a major issue in construction engineering and the researches regarding the effectiveness of using natural wastes are rapidly increasing. The use of natural fibers to reinforce soil is an old and ancient idea. The main aim of this paper, compared to the results obtained on waste plastic and coir fibre materials used separately. Therefore, is to review the, benefits, properties and applications of coir fiber in soil reinforcement through reference to published scientific data.

1. INTRODUCTION

1.1 General

Geotechnical properties of problematic soils such as soft fine-grained and expansive soils are improved by various methods. The problematic soil is removed and replaced by a good quality material or treated using mechanical or chemical stabilization. Different methods can be used to improve and treat the geotechnical properties of the problematic soils (such as strength and the stiffness) by treating it. These methods include densifying treatments (such as compaction or preloading), the bonding of soil particles (by ground freezing, grouting, and chemical stabilization). The chemical stabilization of the problematic soils (soft fine-grained and expansive soils) is very important for many of the geotechnical engineering applications such as pavement structures, roadways, building foundations, channel and reservoir linings, irrigation systems, water lines, and sewer lines to avoid the damage due to the settlement of the soft soil or to the swelling action of the expansive soils. .Method of stabilisation by mixing soil with stabilising agents or binders have been well established to improve engineering properties of the ground which results in improved bearing capacity and reduced settlements under imposed loads.Plastics are considered as one of the important invention which has remarkably assisted in different aspects of life whether it might be in scientific field or others. The use of plastic has been enormously increasing these days. But now, plastic has become the significant pollutant of Environment because of the Use and Throw mechanism and everyone should think about this in the present scenario. The use of plastic has to be limited by now otherwise there would be harshly circumstance that human and environment has to face in near future. Since Plastic is a non-decomposable material, the necessity for recycling or reusing it, is also increasing thereby reducing its wastage. Utilizing this Plastic waste for a positive purpose assists in reducing its effect on environment also. 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 mattressfibres 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 behaviour 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

1.2 NEED OF SOIL STABILIZATION:

- Soil stabilization refers to the process of changing soil properties to improve strength and durability.
- There are many techniques for soil stabilization, including compaction, dewatering and by adding material to the soil.
- Mechanical stabilization improves soil properties by mixing other soil materials with the problematic soil to change the gradation and therefore change the engineering properties.
- Deciding the lacking property of soil and choose effective and economical method of soil stabilization.
- Designing the stabilized soil mix for intended stability and durability values.

1.3 OBJECTIVES :

- To increase the density and California Bearing Ratio (CBR) of soil using plastic as an admixture.
- To provide an alternative solution for the disposal of plastic waste.
- To provide an economical solution for soil stabilization using plastic waste.
- To determine the optimum plastic content to be used.
- To determine the properties of red soil procured.
- To determine Specific gravity, Grain size analysis and determine its index properties of soil.
- To mix plastic strips with Red soil in various percentages and determine its CBR value.
- To arrive the optimum mix from Red Soil-Plastic strips combination.
- To manage the indecomposable and upgradable plastic waste.
- To alter the soil condition in the site by using low cost plastic waste.

2. METHODS OF SOIL STABILIZATION

There are different materials in utilization for the stabilization of soils. Depending on the internal factor which describes the bonding between the soil and the stabilizer utilized, the methods are broadly classified into two types.

2.1. Mechanical Stabilization:

It is based on the principle of friction i.e., when the admixtures are added to soil and compacted the strength is enhanced due to the friction between the soil and the material added. Examples for the materials which increase the strength by this principle are sand, plastic, geo textiles etc.

2.2. Chemical Stabilization:

It is based on the chemical reaction between the material added and the minerals in soil. Examples for this type of stabilizers are lime, fly ash, bituminous materials, cement etc.

3. SOIL STABILIZATION METHODS

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

3.1 In–Situ Stabilization

The method involves on site soil improvement by applying stabilizing agent without removing the bulk soil. Thistechnology offer benefit of improving soils for deep foundations, shallow foundations and contaminated sites. Planningof the design mix involves the selection and assessment of engineering properties of stabilized soil and improvedground. 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 canbe accomplished by injection into soils a cementious material such cement and lime in dry or wet forms. The choice toeither use dry or wet deep mixing methods depend among other things; the in-situ soil conditions, in situ moisturecontents, effectiveness of binders to be used, and the nature of construction to be founded. Depending on the depth oftreatment, the in situ stabilization may be regarded as either deep mixing method or mass stabilization.

3.2 Deep Mixing Method

The deep mixing method involves the stabilization of soils at large depth. It is an in situ ground modificationtechnology in which a wet or dry binder is injected into the ground and blended with in situ soft soils (clay, peat ororganic soils) by mechanical or rotary mixing Tool. Depending on applications, the following patterns may beproduced; single patterns, block patterns, panel pattern or stabilized grid pattern.

Note that, the aim is to produce thestabilized soil mass which may interact with natural soil and not, to produce too stiffly stabilized soil mass like a rigidpile which may independently carry out the design load. The increased strength and stiffness of stabilized soil shouldnot, therefore, prevent an effective interaction and load distribution between the stabilized soil and natural soil.

3.3 Wet Mixing

Applications of wet deep mixing involve binder turned into slurry form, which is then injected into the soil through thenozzles located at the end of the soil auger. The mixing tool comprise of drilling rod, transverse beams and a drill endwith head. There are some modifications to suit the need and applications. For instance, the Trench cutting Re-mixingdeep method (TRD) developed by circa Japan, in 1993 provides an effective tool for construction of continuous cutoffwall without the need for open trench. The method uses a crawler-mounted, chainsaw-like mixing tool to blend in-situsoil 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.

3.4 Dry Mixing

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

4. TYPES OF STABILIZATION TECHNIQUES

4.1 Cement Stabilization

Soil is basically combined and mixed with cement to add strength and durability. The end result is fairly durable and resistant to weather, making it a great choice for sandy soil environments.

4.2 Lime Stabilization

This procedure is not nearly as cost-effective as cement, and it can be more expensive due to the cost of the burnt limestone required for the process. It is also bad for the environment.

4.3 Chemical Stabilization

Most of the chemicals used in these processes are dangerous for the environment though, and they can be quite expensive as well.

4.4 Polymer Stabilization

They involve combining the soil with non-reactive, environmentally neutral polymer based filler material.

5. MATERIALS

The materials used in the experiments are soil, waste plastic and Coconut coir Fibre.

5.1 Waste Plastic:

Plastic and materials made with plastic have become the integral part of our day to day life in various stages and also in various forms, but then, the disposal and dumping of the used and unwanted plastic has become a major threat for the civilized society, as the production and usage of new plastic and plastic associated materials are not in balance with its recycling recycled plastic products status. Plastic bottle and plastic bags recycling has not kept pace with the dramatic increase in virgin resin polyethylene Terephthalate (PET) sales and the aspect of reduce / reuse / recycle, has emerged as the one that needs to be given prominence. The general survey shows that 1500 bottles are dumped as garbage every second. PET is reported as one of the most abundant plastics in solid urban waste whose effective reuse/recycling is one of the critical issue which needs immediate attention

Fig5.1 waste plastic

5.2 WHY PLASTIC IS USED?

Plastic is increases the shear strength and also California bearing ratio of the soil. It can significantly enhance the properties of the soil used in the construction of road infrastructure and available abundance.

Table 1.Properties And Specification Of Waste Plastic

Property	Specifications
Length	3mm
Breadth	20mm
Thickness	0.5mm
Dry Density	1450 Kg/M^3

5.3 COIR FIBRE:

Coconut coir Fibre is obtained from the husk of coconut and belongs to the group of hard structural fibres. The fibrous husks are soaked in pits or in nets in a slow moving body of water to swell and soften the fibres. The long bristle fibres are separated fromshorter mattress fibres underneath the skin of nut, a

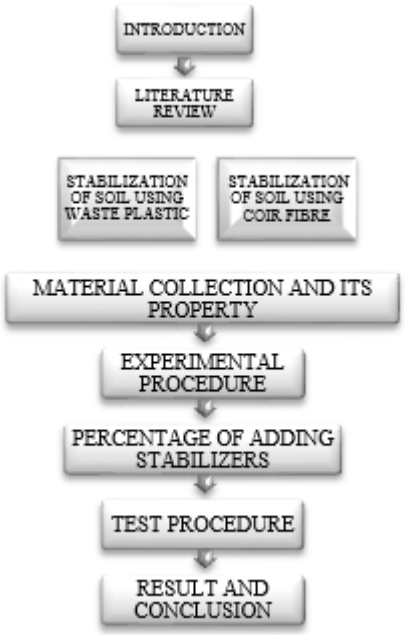
process known as wet milling. The coir Fibre is elastic enough to twist without breaking and it holds a curl as though permanently waved. It is an important commercial product used in mattress. Shorter mattress fibres are separated from the long bristle fibres which are in turn a waste in the coir Fibre industry. The coir is purchased from market. It is the fibrous portion of the coconut extracted mainly from the green nut. Coir extracted consists of rotting the husk in water and removing the organic material binding the fibre. Diameter is 0.1mm. The coir is cut into pieces of 15mm as those percentage remains 0.25, 0.50, 0.75, 1%.

Fig5.3 Coconut coir Fibre

Table 2 Properties And Specifications Of Coir Fibre

Property	Specification
Length	15mm
Density	1.4 G/Cc
Diameter	0.1mm
Major Proteins Present	Lignin, Cellulose

6. METHODOLOGY



6.1 TESTS CONDUCTED

The various tests conducted to obtain geotechnical parameters are:

a. Grain Size analysis of soil

b. Liquid Limit

c. Plastic Limit

d. Shrinkage limit

e. Specific gravity

f. direct shear test

g. California bearing ratio test

h.Unconfined compression test

It must be stabilized with soil stabilizers to gain the strength. The soil must be stabilized otherwise it may not satisfy the requirement as pavement material. This is not only economic solution, but offers a potential use of industrial/domestic waste materials.The various index and engineering properties of the soil sample collected were determined first, using the various standard tests.

6.1.1 Grain Size Analysis:

Grain size analysis has been conducted on the soil sample as per IS 2720 (Part IV) 1985. Washing has been conducted to determine the percentage of Fine Grains and Coarse Grains in the soil sample.Determination of percentage of differentgrainsizes in soil passing through 4.75 is sieve andretained on 75-micron is sieve.A grain size distribution curve is also used todetermine the coefficient of uniformity Cu andcoefficient of curvature Cc

$Cc = (D30)^2 / (D10 * D60)$

Where,

D60 = diameter of particles corresponding to 60%fines;

D10 = diameter of particles

corresponding to 10% fines, also known as effective size;

D30 =diameter of particles corresponding to 30 % fines.

PROCEDURE:

1. Take 500gm oven dried sample passing throughIS sieve 4.75mm. Clean the different sizes of sieve with brushes and weigh all sieves separately in balance.

2. Assemble sieve in ascending order ofsizes i.e. 4.75mm, 2.36mm, 1.18mm, 600µ, 300µ, 150µ, 75µ and pan. Carefully pour the soil sample into top sieve and place lid on top.

3. Place the sieve stack uses mechanical shakerand shake for 10 minutes.

4. Remove the stack from the shaker

Sieve Analysis of Fraction Passing 4.75mm IS

C_u-efficient of curvature

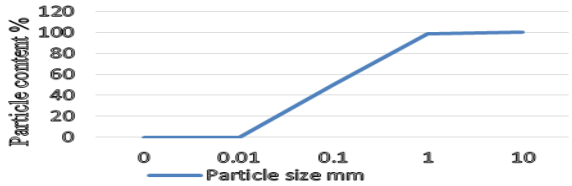
$Cc = (D30)^2 / (D10 * D60) = 1.457$

Uniformity co-efficient – Cu

$=D60 / D10 = 3.44$

Soil is coarse grained as more than 50 % soil is retained on 75 micron sieve. Since greater than 50 % passes through 4.75 mm so it's coarse grained sand.

The Cc value is between 1 and 3, hence its well graded but as Cu is less than 6, and the soil is poorly graded sand.



6.1.2 Specific Gravity:

Specific Gravity Test The specific gravity (G) has been determined using Pycnometer as per IS 2720 (Part III/sec I) 1980.

6.1.3 Consistency Limits:

The liquid limit has been determined using Casagrande Apparatus. The Plastic Limit has been determined by rolling a thread of 3mm diameter. The shrinkage limit has been determined using shrinkage Dishes.

6.1.4 Standard Proctor Test:

Standard Proctor Test has been conducted as per IS 2720 Part (XXVIII). The Dry Density has been determined and has been plotted against the corresponding water Content to find the Optimum moisture Content and the Maximum Dry density.

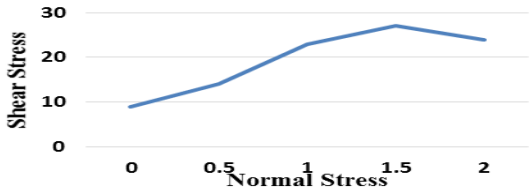
The test has been conducted in soil admixed with plastic bottle strips of different aspect ratios (10mmX10mm, 30mmX10mm and 40mmx10mm) with varying quantities (0.25%, 0.50% and 1.00% by weight of soil sample taken).

6.1.5 Direct Shear Test:

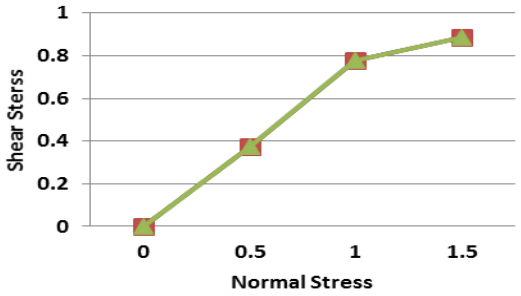
A direct shear test is a laboratory or field test used by geotechnical engineers to measure the shear strength properties of soil or rock material, or of discontinuities in soil or rock masses.

The angle of internal friction (ϕ) and the Cohesion (c) of the plane soil sample have been determined by conducting Direct shear Test. The normal Stress against Shear Stress curve has been plotted and the results have obtained from the curve. Strain controlled direct shear machine consists of shear box, soil container, loading unit, proving ring, dial gauge to measure shear deformation and volume changes. A two piece square shear box is one type of soil container used.A proving ring is used to indicate the shear load taken by the soil initiated in the shearing plane.

Maximum percentage of waste plastic with redsoil



Maximum percentage of coir fibre with red soil



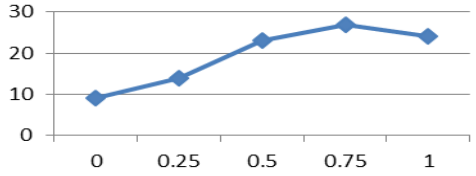
California Bearing Ratio:

California Bearing Ratio Test has been toconducted to determine the CBR value of soil sample. The test has done with procedure conforming to Indian standards (IS 2720 Part XVI: 1979).

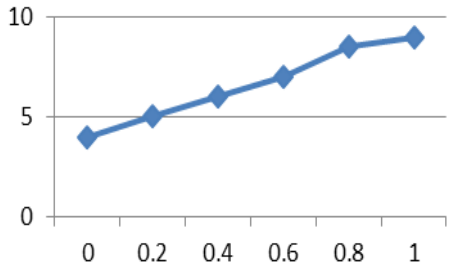
The test has been conducted in soil admixed with plastic bottle strips of different aspect ratios (10mmX10mm, 30mmX10mm) with varying quantities(0.25%, 0.50% , 0.75% and 1.00% by weight of soil sample taken).

The load penetration curves so obtained was done by taking the varying aspect ratio as 1,2,3 and 5 and also at different strip content as 0.25%, 0.5%, 0.75% and 1% with one sample with 0%. The so observed from the experiment is plotted in the figure enlisted below and from this various conclusions can be drawn.

CBR for Waste Plastic



CBR for Coir Fibre



Advantages of stabilization are summarized below:

1) Improved stiffness and tensile strength of the material

2) Reduction in pavement thickness

3) Improved durability and resistance to the effect of water

6.2 APPLICATIONS OF SOIL STABILIZATION

The process of soil stabilization is useful in the following applications:

- Reducing the permeability of soils.
- Increasing the bearing capacity of foundation soils.
- Increasing the shear strength of soils.
- Improving the durability under adverse moisture and stress conditions.
- Improving the natural soils for the construction of highways and airfields.
- Controlling the grading of soils and aggregates in the construction of bases and sub bases of the highway and airfields.

7. DISCUSSIONS OF THE RESULTS

From the paper various conclusion in the aspect of strength, cost and other various field can be recommended. Plastic can be one of the material which can be used as a soil stabilizing agent but the proper proportion of this must be there, which aids in increasing the CBR of the soil and also when the aspect ratio is increased then the strength parameter is also increased. The load penetration curves so obtained was done by taking the varying aspect ratio as 1,2,3 and 5 and also at different strip content as 0.25%, 0.5% and 1% with one sample with 0%. It is very much clear that mixing of the strip in the soil can increase the strength of the soil because the soil sample without the strip is having less strengthAspect ratio also increase the CBR value 0.75% and plastic strip decreased whereas in 1% plastic strip added. This all implies that benefits ofincreases stability to certain level and after that it will decrease the strength so careful observation must be done. All this shows that plastic strips can be used as a reinforcing materials in stabilization of the sub grade soil if used in right proportion. This can be used for stabilization of soil of embankment, pavement sub grade and other different fields as per the needs and flexibility. Further research is advisable for its more effectiveness.

8. CONCLUSION

When the test was done due consideration was taken care of and minimum fault due to instrument and environment were also taken into consideration. The soil sheared during penetration, strip fixed in the soil by friction, elongated and collectively provided strength against the deformation during the test. After analyzing the test results between the comparision of waste plastic and coir fibre, it has been found that on adding plastic strips into the soil, there has been a positive impact on properties of soil and increases the bearing capacity of the red soil. So use of plastic as a soil stabilizer in road soil sub-grade can be recommended as it increases the CBR value and make the soil stability. It has been found that the maximum CBR is obtained when the waste plastic is added upto 0.75% but the coir fibre stabilized the soil is lesser than waste plastic.The gradual increase in this value indicated that use to plastic strip can modify the soil characteristics and helps to provide the strength to the soil.

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