EXPERIMENTAL INVESTIGATION ON CLAYEY SOIL REINFORCED WITH POLYESTER (RECRON -3S) FIBRES

Kodurupaka Rajesh[1], Adep Dhanalaxmi[2], Velugandula Vaishnavi[3]
[1]*Assistant Professor, Vaageswari College of Engineering, Karimnagar.*
[2,3]*B.tech IV year Students, Vaageswari College of Engineering, Karimnagar.*
Email: rajesh.vitsce@gmail.com

ABSTRACT

Soil reinforcement is defined as a technique to improve the engineering characteristics of soil. In this way, using natural fibers to reinforce soil is an old and ancient idea. Consequently, randomly distributed fiber reinforced soils have recently attracted increasing attention in geotechnical engineering for the second time. The objective of this project is to identify a synthetic fiber to enhance the shear strength and bearing capacity of a cohesive soil. This study includes investigation of the reinforced soil and determination of the optimum reinforcement in terms of fiber's content and length by conducting Proctor Density Test and Direct Shear Test.

Key words: Stabilisation ,Soil Reinforcement,

INTRODUCTION

For any land-based structure, the foundation is very important and has to be strong to support the entire structure. In order for the foundation to be strong, the soil around it plays a very critical role. So, to work with soils, we need to have proper knowledge about their properties and factors which affect their behavior. The process of soil stabilisation helps to achieve the required properties in a soil needed for the construction work.

From the beginning of construction work, the necessity of enhancing soil properties has come to the light. Ancient civilizations of the Chinese, Romans and Incas utilized various methods to improve soil strength etc., some of these methods were so effective that their buildings and roads still exist.

In India, the modern era of soil stabilisation began in early 1970's, with a general shortage of petroleum and aggregates, it became necessary for the engineers to look at means to improve soil other than replacing the poor soil at the building site. Soil stabilisation

was used but due to the use of obsolete methods and also due to the absence of proper technique, soil stabilisation lost favor. In recent times, with the increase in the demand for infrastructure, raw materials and fuel, soil stabilisation has started to take a new shape. With the availability of better research, materials and equipment, it is emerging as a popular and cost-effective method for soil improvement.

Soil can often be regarded as a combination of four basic types: Gravel, sand, clay, and silt. It generally has low tensile and shear strengths. On the other hand, reinforcement consists of incorporating certain materials with some desired properties within other material which lack those properties. Therefore, soil reinforcement is defined as a technique to improve the engineering characteristics of soil in order to develop the parameters such as shear strength, compressibility, density and hydraulic conductivity. The primary purpose of reinforcing soil mass with fibers is to improve its stability, to increase its bearing capacity, and to reduce settlements and lateral deformation.

1.1HISTORY

- The concept of fiber reinforcement was recognized more than 5000 years ago.
- The Mesopotamians and Romans separately discovered that it was possible to improve the ability of pathways to carry traffic by mixing the weak soils with a stabilizing agent like pulverized Limestone or calcium.
- Ancient civilizations used straw and hay to reinforce mud blocks in order to create reinforced building blocks.
- Example of reinforcing the soil like Great Wall of China (earliest example of reinforced earth using branches of trees as tensile elements), ziggurats of Babylon (woven mats of read were used), etc.
- In the modern history, the concept and principle of soil reinforcement was first developed by Vidal. He introduces the reinforcing elements in a soil mass which can increases the shear resistance. Vidal in 1966, nearly 4000 structures have been built in more than 37 countries.
- Firstly, polyester filaments before staple fibers entered to the geotechnical engineering market under the traditional brand of ‘‘Texsol’’. This product was used in retaining walls and for slope protections.
- Randomly distributed fiber-reinforced soils, known as short fiber soil composites, have recently

attracted increasing attention in many geotechnical engineering applications.

- Synthetic staple fibers have been used in soil since the late 1980s, when the initial studies using polymeric fibers were conducted.

1.1.1 Classification of Fibers

The reinforcing fibers can be broadly classified into two categories. They are:

(a) Natural Fibers

(b) Synthetic Fibers(Man-made)

(a) Natural Fibers

At the present time, there is a greater awareness that landfills are filling up, resources are being used up, the planet is being polluted and that non-renewable resources will not last forever. So, there is a need to more environmentally friendly materials.

(b) Synthetic Fibers

Synthetic fibers are made from synthesized polymers (or) small molecules. The compounds that are used to make these fibers are from raw materials such as petro chemicals. Synthetic (chemically produced) fibers are made by joining monomers into polymers, through a process called polymerization. A synthetic fiber, when magnified, looks like plastic spun together. Chemicals used to make synthetic fibers include sodium hydroxide and carbon disulphide, which are derived from coal, oil, or natural gas.

LITERATURE REVIEW

2.1 SOIL STABILISATION

2.1.1 Definition

Soil stabilisation is the process of altering some soil properties by different methods, mechanical or chemical in order to produce an improved soil material which has all the desired engineering properties.

Soils are generally stabilised to increase their strength and durability or to prevent erosion and dust formation in soils. The main aim is the creation of a soil material or system that will hold under the design use conditions and for the designed life of the engineering project. The properties of soil vary a great deal at different places or in certain cases even at one place; the success of soil stabilisation depends on soil testing. Various methods are employed to stabilize soil and the method should be verified in the lab with the soil material before applying it on the field.

Principles of Soil Stabilisation:

- Evaluating the soil properties of the area under consideration.
- Deciding the property of soil which needs to be altered to get the design value and choose the effective and economical method for stabilisation.
- Designing the Stabilised soil mix sample and testing it in the lab for intended stability and durability values.

2.1.2 Needs & Advantages

Soil properties vary a great deal and construction of structures depends a lot on the bearing capacity of the soil, hence, we need to stabilize the soil which makes it easier to predict the load bearing capacity of the soil and even improve the load bearing capacity. The gradation of the soil is also a very important property to keep in mind while working with soils. The soils may be well-graded which is desirable as it has less number of voids or uniformly graded which though sounds stable but has more voids. Thus, it is better to mix different types of soils together to improve the soil strength properties. It is very expensive to replace the inferior soil entirely soil and hence, soil stabilisation is the thing to look for in these cases.

- It improves the strength of the soil, thus, increasing the soil bearing capacity.
- It is more economical both in terms of cost and energy to increase the bearing capacity of the soil rather than going for deep foundation or raft foundation.
- It is also used to provide more stability to the soil in slopes or other such places.
- Sometimes soil stabilisation is also used to prevent soil erosion or formation of dust, which is very useful especially in dry and arid weather.
- Stabilisation is also done for soil water-proofing; this prevents water from entering into the soil and hence helps the soil from losing its strength.
- It helps in reducing the soil volume change due to change in temperature or moisture content.
- Stabilisation improves the workability and the durability of the soil.

2.1.3 Methods of Soil Stabilisation

Mechanical method of Stabilisation

In this procedure, soils of different gradations are mixed together to obtain the desired property in the soil. This may be done at the site or at some other place from where it can be transported easily. The final mixture is then compacted by the usual methods to get the required density.

Additive method of stabilisation

It refers to the addition of manufactured products into the soil, which in proper quantities enhances the quality of the soil. Materials such as cement, lime, bitumen, fly ash etc. are used as chemical additives. Sometimes different fibers are also used as reinforcements in the soil. The addition of these fibers takes place by two methods;

(a) Oriented fiber reinforcement

The fibers are arranged in some order and all the fibers are placed in the same orientation. The fibers are laid layer by layer in this type of orientation. Continuous fibers in the form of sheets, strips or bars etc. are used systematically in this type of arrangement.

(b) Random fiber reinforcement

This arrangement has discrete fibers distributed randomly in the soil mass. The mixing is done until the soil and the reinforcement form a more or less homogeneous mixture. Materials used in this type of reinforcements aregenerally derived from paper, nylon, metals or other materials having varied physical properties.

Randomly distributed fibers have someadvantages over the systematically distributed fibers. Somehow this way of reinforcement is similar to addition of admixtures such as cement, lime etc. Besides being easy to add and mix, this method also offers strength isotropy, decreases chance of potential weak planes which occur in the other case and provides ductility to the soil.

METHODOLOGY

3.1 SELECTION CRITERIA

After we reviewed many fiber reinforcement papers, we determined that the fiber selection parameters were the following:It must not be a hazard to its surroundings.

- It should not degrade so easily in the soil.
- It must be easily obtainable and inexpensive.
- Its preparation and inclusion method should be simple.
- It must work with the selected soil.

We evaluated the following fibers to select for the study:

1. **Natural fibers:** As the natural fibers are bio-degradable, they cannot serve in the entire design period. These require coating of chemicals that inhibit them from degradation. The process of refining fibers, applying glue and coating is a tough task.
2. **Polypropylene fibers (Recron 3S):** These fibers are less costly but degrade easily under direct soil exposure and they are not easily available locally.
3. **Polyester fiber (Recron 3S):** Polyester fiber is locally available in our study area. These are comparatively less in cost. Works good with red clayey soils and black cotton soils. Inclusion of this fiber in the soil matrix is simple and requires less energy. It has high strength and flexibility. It also provides high resistance to abrasion and physical forces.
4. **Glass fiber:** Glass fiber is a costly material. Works good with concrete but not with soil. It is not locally available in our area.
5. **Nylon fiber:** It is widely used for fabrics manufacturing. Not recommended for soil reinforcement.

6. PVC fiber: Polyvinylchloride fiber is designed to reinforce plastic materials and seat covers, etc. This fiber has a significant negative environmental effect if used as reinforcement to

soil.

After evaluation, we preferred to go with Synthetic fiber that is locally available, can work with selected soil, has low cost and has no significant environmental effect. Therefore we selected Polyester fiber as the reinforcement material for this study.

As12mm and 18mmfibersarenotsuitablefor laboratoryexperiments,we havechosentouse 6mm fiber.

WehavepurchasedtheRecron3S(Polyester)fiberm anufacturedbyRelianceIndustriesLimited from Vasanth enterprises private limited,Punjagutta, Hyderabad.

3.2 POLYESTER (RECRON 3S) FIBER:

Recron3Sisamodifiedpolyesterfiber.I tisgenerallyusedassecondaryreinforcingm aterialinconcreteandsoiltoincreasetheirper formance.Recron3Ssamplesusedinexperi mentwasof6mmlength,manufacturedbyRe lianceIndustriesLimited.Physicalparamete rsofRecron3Sfiberasobtainedfrom RILSaf etydatasheetaregiveninTable 3.UseofRecron 3Sasareinforcingmaterialistoincreasethest rengthinvariousapplicationslikecementbas edprecastproducts,filtrationfabricsetc.Itals oprovidesresistancetoimpact,abrasionand greatlyimprovesthequalityofconstructiond uringfoundation,retainingwalldesignetc.P olyesterfiberisthemostwidelyusedinclusio ninlaboratorytestingofsoilreinforcement. Currentlythisfiberisusedtoenhancethesoils trengthproperties,toreducetheshrinkagepr opertiesandtoovercomechemicalandbiolo gicaldegradation.Duringlast25years,much workhasbeendoneonstrengthdeformationbeha vioroffiberreinforcedsoilandithasbeenestablis hedbeyonddoubtthatadditionoffiberinsoilimpr ovestheoverallengineeringperformanceofsoil. Amongall,thenotablepropertiesthatimproveda regreaterextensibility,smalllossofpostpeakstre ngth,isotropyinstrengthandabsenceofplanesof weakness.Fiberreinforcedsoilhasbeenusedinm anycountriesintherecentpastandfurtherresearc hisinprogress formanyhidden aspects of it.

Fig.1 - Recron 3Sfiberpackets manufactured byRelianceIndustriesLtd.

3.3 TESTING METHODOLOGY

Parentsoilistestedforitsindexproperties,drydensitybyproctorcompactiontestandshearstrengthwerecarriedoutaspertheproceduresandguidelineslaiddowninIndianStandardsCodesofpractice. AtotalofninesamplesofsoilRecron3Sfibermixtureweremade(0.1%,0.2%,0.3%,0.4%,0.5%,0.6%,0.7%,0.8%and0.9%ofthetotaldryweightofthesoil). Afterthedeterminationofvariousindexpropertiesofsoil,Proctorcompactiontestswereconducted, followed bydirect shear tests on the reinforced soil.

4.3RESULTS AND DISCUSSION

4.3.1 DISCUSSION ON COMPACTION TEST RESULTS

From the results it is observed that the parent soil initially has Dry Density (γdry) equal to 1.70 gm/cc. There is a considerable increase in its Dry Density when reinforced with 6mm fiber. The Dry Density is continuously increased up-to the inclusion of 0.6% of fiber by weight. But further increase of fiber content lead to decrease in Dry Density. Optimum Moisture Content of the soil is continuously increased with increase in fiber content. From this we concluded that optimum fiber content is 0.6% and due to this percentage fiber inclusion the Dry Density of soil is increased from 1.70 to 1.94 gr/cc. Therefore percentage increase of Dry Density is observed to be 14.11 % .

It is observed from tests that the 6mm fiber is much effective in improving Dry Density of the test soil.

4.4 DISCUSSION ON DIRECT SHEAR TEST RESULTS

Shear Strength of parent soil sample is found to be 0.0323 Kg/Cm2. Due to inclusion

of 6mm fiber, it is continuously increased up to the fiber content of 0.4% after which it has decreased. Therefore, the optimum 6mm fiber content is observed to be 0.4%. At this fiber content the Shear Strength is 0.0363 Kg/Cm2. Hence, increase of shear strength and cohesion due to optimum fiber content inclusion are 12.38% and 36% respectively.

It is observed from tests that the 6mm fiber is much effective in improving shear strength of the parent soil.

CONCLUSIONS

From the results of Proctor Compaction Test, it is found that the Dry Density of soil sample is increased continuously up to optimum fiber content i.e. 0.6% for 6 mm. This happens due to reduction in void ratio of soil matrix. Further addition of fiber has reduced density by a great extent. It may be happened due to the fact that the fiber content is more than the voids it can fill and due to the increase of voids at the contact surface area of the fiber strands. From figures, it can also be noted that 6mm fiber is more effective in improving Dry density of the soil. Therefore inclusion of 0.6% of 6mm fiber is recommended for reinforcing this soil. Based on direct shear test on 6mm fiber samples, with fiber reinforcement of 0.2%, 0.4% 0.6% and 0.8%, the net increase in cohesion was found to be 36% for 6mm fiber. The increase in the Shear strength (τ) is found to be 12.3% for 6mm fiber. From this it can be concluded that 6mm fiber aparts more strength to the soil and is recommended over parent soil. Overall it is concluded that 6mm Recron 3S (Polyester) fiber is most effective in improving the strength of selected soil if added to the soil in the rage of 0.4% to 0.6% by weight of soil. It is also observed that random inclusion method is considerably good and cost effective for stabilizing the soil.

REFERENCES

1. S. A. Naeini and S. M. Sadjadi ,(2008) ," Effect of Waste Polymer Materials on Shear Strength of Unsaturated Clays", EJGE Journal, Vol 13, Bund k,(1-12).
2. Yetimoglu, T., Inanir, M., Inanir, O.E., 2005. A study on bearing capacity of randomly distributed unreinforced sand fills overlying soft clay. Geotextiles and Geomembranes 23 (2), 174–183.
3. Mahmood R. Abdi, Ali Parsapajouh, and Mohammad A. Arjomand,(2008)," Effects of Random Fiber Inclusion on Consolidation, Hydraulic Conductivity, Swelling, Shrinkage Limit and Desiccation Cracking of Clays", International Journal of Civil Engineering, Vol. 6, No. 4, (284-292).
4. Consoli, N. C., Prietto, P. D. M. and Ulbrich, L. A. (1999). ''The behavior of a fibre- reinforced cemented soil.'' Ground Improvement, London, 3(1), 21–30.
5. IS 2720 – part (xiii) 1980-87
6. The need for soil stabilisation, April 9, 2011 by Ana [online] Available at:

http://www.contracostalandscaping.com/the-need-for-soil-stabilisation

7. Methods of soil stabilisation, December 24, 2010 [online] Available at: http://www.engineeringtraining.tpub.com/14070/css/14070_424.htm
8. Prof. Krishna Reddy, UIC, 2008, Engineering Properties of Soils Based on Laboratory Testing.
9. Understanding the Basics of Soil Stabilisation: An Overview of Materials and Techniques [online] Available at : http://www.cat.com
10. Punmia B.C. 2007, "Soil Mechanics & Foundations" Laxmi Publications
11. Yadav Parit, Meena Kuldeep Kumar, (2011)" A comparative study in soil plasticity of Hall area and lecture complex area of NIT Rourkela" B.tech thesis, NIT,Rourkela.
12. IS: 2720(Part 2), 1973 Methods of Test for Soils, Determination of water content.