TECH-CHRONICLE
AN INTERNATIONAL E-JOURNAL ON
EMERGING TRENDS IN SCIENCE, TECHNOLOGY AND MANAGEMENT

Soil Stabilization Using Polypropylene Fibre

SailiWankhede[a], RswapnilBardekar[a], AtulKhobragade[a], SulabhBagde[a]
VaibhavBorkar[a], SumedhDongre[a], PintuPatil[a], Prof.Mrs. NimitaGautam[b]
[a]U. G. Student, TulsiramjiGaikwad-Patil College of Engineering and Technology, Mohgaon, Nagpur, INDIA
[b]Assisstant Professor, TulsiramjiGaikwad-Patil College of Engineering and Technology, Mohgaon, Nagpur, INDIA

***Abstract*—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 stabilization 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 stabilization 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 stabilization was used but due to the use of obsolete methods and also due to the absence of proper technique, soil stabilization lost favor.In this project, soil stabilization has been done with the help of randomly distributed polypropylene fibers obtained from waste materials. The improvement in the shear strength parameters has been stressed upon and comparative studies have been carried out using different methods of shear resistance measurement.**

Keywords—foundation; stabilization;polypropylenefibers; shear resistance

I. INTRODUCTION

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 stabilization 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 stabilization was used but due to the use of obsolete methods and also due to the absence of proper technique, soil stabilization lost favor.Soil stabilization 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 stabilized 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 stabilization 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 [1-3].

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 stabilization 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 [2-4].

The principles involved in soil stabilization includes: Deciding the property of soil which needs to be altered to get the design value and choose the effective and economical method for stabilization; Designing the Stabilized soil mix sample and testing it in the lab for intended stability and durability values; Evaluating the soil properties of the area under consideration [4-5]. The different methods of soil stabilization includes: Mechanical method of Stabilization-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 [3]; Additive method of stabilization-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 [6]. 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. Continuousfibers 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 are generally derived from paper, nylon, metals or other materials having varied physical properties.Randomly distributed fibers have some advantages 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 [7-8].

II. LITERATURE REVIEW

Peat soil is well known to deform and fail under a light surcharge load and is characterized with low shear strength, high compressibility and high water content. With the rising demand from the construction industry, utilization of these soils is required and suitable technique needs to be found out for stabilizing them. Approach: Model study had been carried to stabilize peat soil using cement as binding agent and polypropylene fibers as additive. Due to high natural water content of the peat soil, the stabilized peat soil samples were kept at normal room temperature and relative humidity for air curing for 90 days.The improvement in the mechanical strength of the stabilized samples was studied by California Bearing Ratio (CBR) test for both, unsoaked and soaked samples. The water-cement ratio of the samples was measured for 180 days to study the improvement in strength over time. Results: The results of CBR tests showed an increase by a factor over 22 for unsoaked condition and 15 for the soaked condition of the stabilized samples. With the addition of the polypropylene fibers to the stabilized peat soil with cement not only improved the strength of the stabilized peat soil but also contributed to considerable amount of uniformity and intactness to the stabilized peat soil samples.It was also observed that as the curing time for the stabilized peat soil continued through 180 days the moisture content continued to decrease as well. Thus the water-cement (w/c) ratio reduced and as a result of cement hydration, the strength stabilized peat soil samples increased in hardness and gained strength through the curing period. Conclusion/Recommendations: Cement and polypropylene fibers can be used to improve the mechanical strength of the soft peat soil by adopting air curing technique. [1].

A laboratory study on the effect of inclusion of polypropylene fibers (PPF) in cement-stabilized windblown sand specimens. Test specimens were prepared with varying admixtures of ordinary Portland cement content (1%, 3%, 5%, 7% and 10 %) and polypropylene fibers (0.1%, 0.2%, and 0.4%) by the weight of dry soil. Along with index property tests, laboratory California Bearing Ratio (CBR) tests were performed to investigate the strength behavior of fiber-reinforced stabilized windblown sand. The test results indicated that adding fiber inclusions in stabilized windblown sand resulted in higher CBR values.These primary conclusions were obtained from this investigation. First, the inclusion of randomly oriented discrete fibers improved the California bearing ratio of wind-blown sand. Second, an optimum fiber content of 0.2% (by the weight of dry soil) was identified for the stabilization of windblown sand. Finally, the inclusion of PPF in cement-stabilized windblown sand with lowercontent of cement (1% and 3%) improved the CBR values better than higher cement content (5% and 7%) [2].

This paper presents an experimental study evaluating the effect of polypropylene fiber on mechanical behaviour of expansive soils. The initial phase of the experimental program includes the study of the effect of polypropylene fiber on maximum dry density and optimum moisture content with different fiber inclusions. Dynamic compaction tests have been conducted on an expansive soil sample with 0%, 0.5%, 0.75%, and 1% polypropylene fiber additions (by dry weight of the soil) and samples have been prepared with the same dry density statically.The second phase of the experimental program focuses on the unconfined compression, tensile and one-dimensional swell behaviour of the unreinforced and reinforced soil samples. Finally it is concluded that mitigation of expansive soils using polypropylene fiber might be an effective method in enhancing the physical and mechanical properties of subsoils on which roads and light buildings are constructed [3].

Since World War II, the military has sought methods for rapid stabilization of weak soils for support of its missions worldwide. Over the past 60 years, cement and lime have been the most effective stabilizers for road and airfield applications, although recent developments show promise from nontraditional stabilizers,such as reinforcing fibers. The benefits derived from fibers may depend on whether they are used alone or in combination with chemical stabilizers. The purpose of the research described in this paper is to investigate the ability of stabilizers to increase the strength of two soft clay soils within 72 hours to support C-17 and C-130 aircraft traffic on contingency airfields.Laboratory test results showed that longer fibers increased the strength and toughness the most for a clay treated only with fibers. For a clay treated with fibers in addition to a chemical stabilizer, shorter fibers increased toughness the most, but the fibers had little effect on strength. Higher dosage rates of fibers had increasing effectiveness, but mixing became difficult for fiber contents above 1%. Polyvinyl alcohol (PVA) fibers were anticipated to perform better than other inert fibers due to hydrogen bonding between the fibers and clay minerals, but these fibers performed similar to other fibers [4].

Improvement of shear strength of the soil may be undertaken by a variety of ground improvement techniques like stabilization of soil, adoption of reinforced earth techniques like stabilization of soil, adoption of reinforced earth techniques etc. reinforced earth technique is considered as an effective ground improvement method because of it's cost effectiveness, easy adaptability and reproducibility. In the present investigation, the waste polymer materials has been chosen as the reinforcement material and it was randomly included in to the clayey soils with different plasticity indexes at five different percentages of fiber content (0%, 1%, 2%,3%, 4%) by weight of raw soil. the main objective of this study had been focused on the strength behavior of the unsaturated clayey soils. reinforced with randomly included waste polymer fiber. the reinforced soil samples were subjected to direct shear tests. The results have clearly shown a significant improvement in the shear strength parameters (C and φ) of the treated soils. The reinforcement benefit increased with an increase in fiber contents [5].

Scrap tires are being produced and accumulated in large volumes causing an increasing threat to the environment. In order to eliminate the negative effect of these depositions and in terms of sustainable development there is great interest in the recycling of these non-hazardous solid wastes. The potential of using rubber from worn tires in many civil engineering works have been studied for more than 20 years. Tire wastes can be used light weight material either in the form of powder, chips, shredded and as a whole. Applications of tire rubber proven to be effective in protecting the environment and conserving natural resources.They are used above and below ground water. Many work regarding the use of scrap tires in geotechnical application have been done especially as embankment materials (Ghani et al, 2002) The reuse application for tire is how the tire are processing basically includes shredding, removing of metal reinforcing and further shredding until the desired materials are achieved. A passenger car tire contains approximately 26% carbon black, 47% natural rubber, 30% of synthetic rubber. India is fabricating one lakh metric ton of recycle rubber which is sold@ Rs 70 per Kg. [6].

The California Bearing Ratio (CBR) Test is a method of evaluating the strength of soil subgrade/sub-base and base course material for flexible pavement. The CBR is a measure of resistance of a material to penetration of standard plunger under controlled density and moisture conditions. The effectiveness of inclusion of randomly distributed fibers in sandy soils for improving the California bearing ratio values is investigated through an experimental investigation.The California Bearing Ratio (CBR) Tests were conducted on fine sand reinforced with randomly distributed discrete polypropylene and coir fibers, under both soaked and unsoaked conditions. The paper describes the load penetration response obtained from CBR tests performed on fine sand. The CBR values of fine sand increase significantly due to inclusion of randomly distributed fibers under soaked and unsoaked conditions. The increase in CBR is as high as 100% due to addition of 1.5% fiber [7].

The main objective of this study is to investigate the use of waste fiber materials in geotechnical applications and to evaluate the effects of waste polypropylene fibers on shear strength of unsaturated soil by carrying out direct shear tests and unconfined compression tests on two different soil samples. The results obtained are compared for the two samples and inferences are drawn towards the usability and effectiveness of fiber reinforcement as a replacement for deep foundation or raft foundation, as a cost effective approach[8].

III. RESEARCH METHODOLGY

Two soil samples from Amravati and Akola region are obtained for this project.

Table 1. Parameters of polypropylene -fiber

Behavior parameters	Values
Fiber type	Single fiber
Unit weight	0.91 g/cm^3
Average diameter	0.034 mm
Average length	12 mm
Breaking tensile strength	350 MPa
Modulus of elasticity	3500 MPa
Fusion point	165 °C
Burning point	590 °C
Acid and alkali resistance	Very good
Dispersibility	Excellent

IV. TEST PERFORMED

1. Specific Gravity of the soil

The specific gravity of soil is the ratio between the weight of the soil solids and weight of equal volume of water. It is measured by the help of a volumetric flask in a very simple experimental setup where the volume of the soil is found out and its weight is divided by the weight of equal volume of water. Specific gravity is always measured in room temperature and reported to the nearest 0.1.

Fig. 1.Specific Gravity by Pycnometer method

2. Atterberg Limitsof the soil

Liquid limit-The Casagrande tool cuts a groove of size 2mm wide at the bottom and 11 mm wide at the top and 8 mm high. The number of blows used for the two soil samples to come in contact is noted down. Graph is plotted taking number of blows on a logarithmic scale on the abscissa and water content on the ordinate. Liquid limit corresponds to 25 blows from the graph.

Plastic limit-This is determined by rolling out soil till its diameter reaches approximately 3 mm and measuring water content for the soil which crumbles on reaching this diameter. Plasticity index (Ip) was also calculated with the help of liquid limit and plastic limit;

IP=WL-WP, WL=Liquid Limit, WP=Plastic Limit

3. Particle size distribution

The results from sieve analysis of the soil when plotted on a semi-log graph with particle diameter or the sieve size as the abscissa with logarithmic axis and the percentage passing as the ordinate gives a clear idea about the particle size distribution.From the help of this curve, D10 and D60 are determined. This D10 is the diameter of the soil below which 10% of the soil particles lie. The ratio of, D10 and D60 gives the uniformity coefficient (Cu) which in turn is a measure of the particle size range.

4. Direct shear test

This test is used to find out the cohesion (c) and the angle of internal friction (φ) of the soil, these are the soil shear strength parameters. The shear strength is one of the most important soil properties and it is required whenever any structure depends on the soil shearing resistance.The test is conducted by putting the soil at OMC and MDD inside the shear box which is made up of two independent parts.A constant normal load (σ) is applied to obtain one value of c and φ. Horizontal load (shearing load) is increased at a constant rate and is applied till the failure point is reached. This load when divided with the area gives the shear strength 'τ' for that particular normal load.

$$\tau = c + \sigma * \tan(\varphi)$$

After repeating the experiment for different normal loads (σ) we obtain a plot which is a straight line with slope equal to angle of internal friction (φ) and intercept equal to the cohesion (c). Direct shear test is the easiest and the quickest way to determine the shear strength parameters of a soil sample. The preparation of the sample is also very easy in this experiment.

Fig. 2.Apparatus of Direct Shear Test

5. Unconfined compression test

This experiment is used to determine the unconfined compressive strength of the soil sample which in turn is used to calculate the unconsolidated, undrained shear strength of unconfined soil.The unconfined compressive strength (qu) is the compressive stress at which the unconfined cylindrical soil sample fails under simple compressive test. The experimental setup constitutes of the compression device and dial gauges for load and deformation.The load was taken for different readings of strain dial gauge starting from ε = 0.005 and increasing by 0.005 at each step. The corrected cross-sectional area was calculated by dividing the area by (1- ε) and then the compressive stress for each step was calculated by dividing the load with the corrected area.

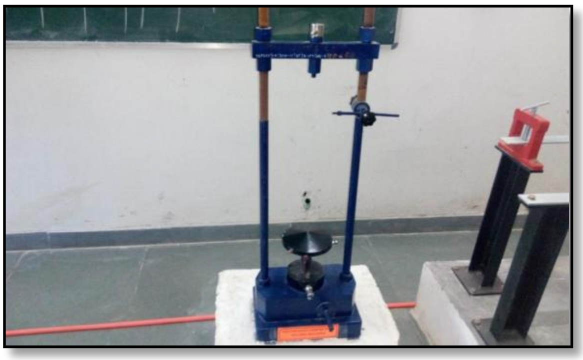

Fig. 3. Apparatus ofUCS

V. RESULT AND DISCUSSION

1. Specific Gravity

Table 2: Specific Gravity of soil sample-1

Sample	1	2	3
Mass of empty bottle (M1) in gms.	128.41	118.67	122.16
Mass of bottle+ dry soil (M2) in gms.	178.41	168.67	172.16
Mass of bottle + dry soil + water (M3) in gms.	401.86	396.29	399.03
Mass of bottle + water (M4) in gms.	369.67	365.378	367.355
specific gravity	2.81	2.62	2.73
Avg. specific gravity	**2.72**		

Table 3: Specific Gravity of soil sample-2

Sample	1	2	3
Mass of empty bottle (M1) in gms.	112.45	114.93	115.27
Mass of bottle+ dry soil (M2) in gms.	162.45	164.93	165.27
Mass of bottle + dry soil + water (M3) in gms.	390.088	395.38	398.16
Mass of bottle + water (M4) in gms.	359.448	364.07	367.87
specific gravity	2.58	2.68	2.54
Avg. specific gravity	**2.60**		

2. Liquid Limit

Liquid limit as obtained from graph = 28.90 (corresponding to 25 blows)

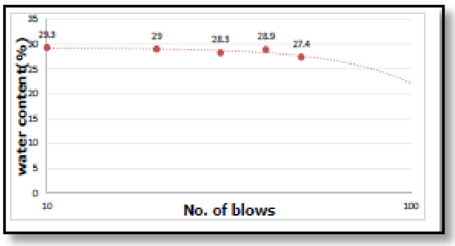

Fig. 4. Liquid limit of soil sample-1

Liquid limit as obtained from graph = 43.491 (Corresponding to 25 blows)

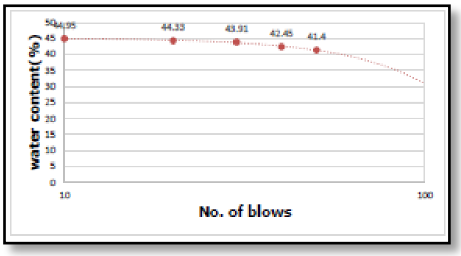

Fig. 5. Liquid limit of soil sample-2

3. Direct Shear Test

Computing from graph,Cohesion(C) =0.325(kg/cm^2), Angle of internal friction (φ) = 47.72°

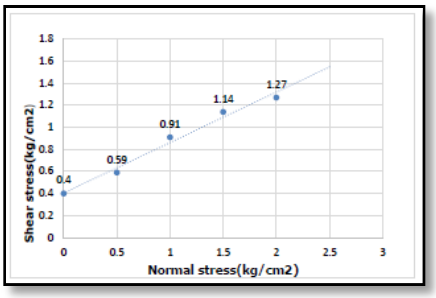

Fig. 6.DST for soil sample-1(unreinforced)

Computing from the graph,Cohesion(C)=0.3513kg/cm^2, Angle of internal friction(φ) =27.82

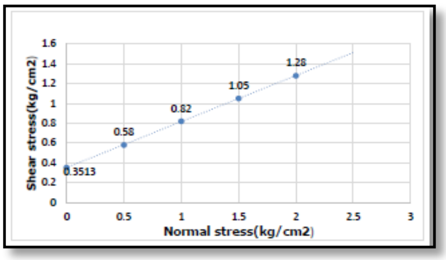

Fig. 7.DST for soil sample-2(unreinforced)

4. Unconfined Compression Strength Test

As obtained from graph,UCS = 0.0567MPa

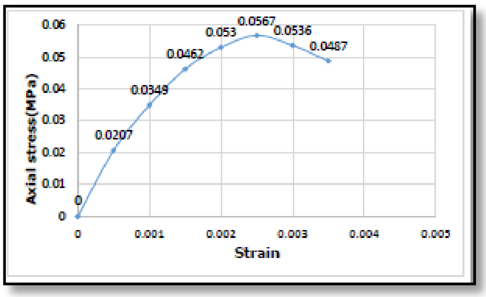

Fig. 8.DST UCS for soil sample-1

As obtained from the graph,UCS = 0.0689 MPa

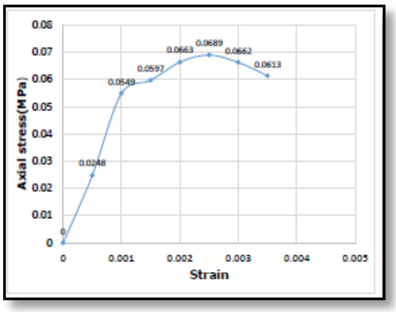

Fig. 9.DST UCS for soil sample-2

VI. Conclusion

Based on the results presented above, the following conclusions can be drawn:

1. Based on direct shear test on soil sample- 1, with fiber reinforcement of 0.05%, 0.15% and 0.25%, the increase in cohesion was found to be 10%, 4.8% and 3.73% respectively. The increase in the internal angle of friction (φ) was found to be 0.8%, 0.31% and 0. 47% respectively. Since the net increase in the values of c and φ were observed to be 19.6%, from 0.325 kg/cm2 to 0.3887 kg/cm2 and 1.59%, from 47.72 to 48.483 degrees respectively, for such a soil, randomly distributed polypropylene fiber reinforcement is not recommended.

2. The results from the UCS test for soil sample- 1 are also similar, for reinforcements of 0.05%, 0.15% and 0.25%, the increase in unconfined compressive strength from the initial value are 11.68%, 1.26% and 0.62% respectively. This increment is not substantial and applying it for soils similar to soil sample- 1 is not effective.

3. The shear strength parameters of soil sample- 2 were determined by direct shear test. Figure- 26 illustrates that the increase in the value of cohesion for fiber reinforcement of 0.05%, 0.15% and 0.25% are 34.7%, 6.09% and 7.07%respectively.

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

VII. Scope for Future Work

1. This research was intended to examine the influence of polypropylene fiber additions in soils.

2. Polypropylene fiber can be effectively replaced in making earthen dams, slopes, quay walls.

3. Since fibers have higher shear strength it is quite valuable to use it than fly ash or lime for soil stabilization.

REFERENCES

[1] 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] 2. Yetimoglu, T., Inanir, M., Inanir, O.E., 2005. A study on bearing capacity of randomly distributed fiber-reinforced sand fills overlying soft clay. Geotextiles and Geomembranes 23 (2), 174–183.

[3] 3. Chaosheng Tang, Bin Shi, Wei Gao, Fengjun Chen, Yi Cai, 2006. Strength and mechanical behavior of short polypropylene fiber reinforced and cement stabilized clayey soil. Geotextiles and Geomembranes 25 (2007) 194–202.

[4] 4. 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).

[5] 5. Consoli, N. C., Prietto, P. D. M. and Ulbrich, L. A. (1999). ''The behavior of a fibrereinforced cemented soil.'' Ground Improvement, London, 3(1), 21–30.

[6] 6. IS 2720 – part (xiii) 1980-87

[7] 7. The need for soil stabilization,April 9, 2011 by Ana [online] Available at: <http://www.contracostalandscaping.com/the-need-for-soil-stabilization/>