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Soil Stabilization using Plastic Fibers

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Abstract

Rapid improvements in the engineering world have influenced the lifestyle of human beings to a great extent. But the day to day activities of mankind are augmenting risks to the environment in the same proportion. Plastic wastes have become one of the major problems for the world. The harmful gas which is being produced by them leads to tremendous health related problems. So, effective engineering implementation of this has become one of the challenging jobs for engineers. In recent years, researchers from various fields have attempted to solve environmental problems caused by the production of non-biodegradable wastes like plastic. Using a geotechnical viewpoint, this paper proposes a partial solution to a major item which piles up in the wastages i.e. Plastic. But the primary objective of this project is to examine the potential capability of stabilizing soil using plastic cover wastes. Various tests such as Standard Proctor, UCC were carried out with different samples to determine the effect of plastic fibers in silty clay. The initial results obtained were promising and supporting the fact of achieving stability of the soil. The advantages of this project results in three folds- Utilization of natural resource (silty clay), Economy, and waste management. Mixing of plastic waste with expansive soil helps to mitigate the volume change behavior of silty clay. Thus the material which was considered as a curse to the environment has turned out to be a boon to the civil engineering community.
Keywords: Soil, Plastic cover, Stabilization, Optimum moisture content (OMC)

I. Introduction

Increased use of plastics in day to day consumer applications has resulted in the municipal solid waste, an ever growing fraction of plastic materials which were used for a short time and then discarded. The linear consumption patterns of plastic bags involving single usage and then disposal has led to environmental challenges such as diminishing landfill space, marine and urban littering. There is, therefore a growing need to find alternative uses of reclaimed plastic bag waste to lengthen the usage time of the plastic material and thereby save the degrading environment. The concept of reinforcing soil masses with strips of plastic cover may be relatively, a new development. In contrast, the use of random-materials as reinforcement for soil is probably not older than written history, but only sparsely represented. The pursuit for improved soil structure and its cost-effectiveness in construction and in slope stabilization forms the basis of this research. This study explored the possibility of utilizing reclaimed plastic material from plastic covers as tensile inclusions to reinforce soil for ground improvement schemes in geotechnical engineering applications such as embankments, slope stabilization, foundation slabs, dams, sea walls, bridge abutment and retaining walls. The specialty of soil reinforcement is its flexibility, which enables construction on poor foundation soil, rapid construction and low cost.

Soil stabilization is any process which improves the engineering properties of soil, such as increasing shear strength, bearing capacity etc. Shear strength is the term used in soil mechanics, to describe the magnitude of the shear stress that a soil can sustain. The shear resistance of soil is resulted from the friction between particles, interlocking of particles, and possibly cementation or bonding at particle contacts. And bearing strength can be geotechnically be defined as capacity of soil to support the loads applied to the ground without causing failure. Thus bearing capacity of soil is the maximum average contact pressure between the foundation and the soil which should not produce shear failure in the soil.

Soil stabilization techniques can broadly be classified into three types namely: - Mechanical: The oldest types of soil stabilization are mechanical in nature. It involves physically changing the property of the soil. Dynamic compaction is one of the major types of soil stabilization, in this procedure a heavy weight is dropped repeatedly onto the ground at regular intervals to quite literally pound out deformities and ensure a uniformly packed surface. Vibro compaction is another technique that works on similar principles, though it relies on vibration rather than deformation through kinetic force to achieve its goals. Chemical: chemical techniques rely on adding an additional material to the soil that will physically interact with it and change its properties. There are a number of different types of soil stabilization that rely on chemical additives of one sort or another, frequently encountered compounds are utilization of cement, lime, fly ash, or kiln dust. Most of the reactions sought are either cementitious or pozzolanic in nature, depending on the nature of the soil. Polymer/Alternative: Most of the newer discoveries and techniques developed thus far are polymer based in nature such as processed polymer fibre or wastage materials such as polythene bags, plastic bottles, recycled plastic pins. These new polymers and substances have a number of significant advantages; they are cheaper and more effective in general than mechanical solutions, and significantly less dangerous for the environment than many chemical solutions.

In this project stabilization is achieved by polymer method, by using plastic covers. The plastic covers were chosen as material for stabilization, as it contributes to 35% chunk of the total plastic wastage. Thus utilizing it in soil stabilization helps to converse the natural resources and reduce the waste heap. Also plastic strip are inert and degradable so it effectively remains in soil for many years.

II. SCOPE AND OBJECTIVE

Increased use of plastics in day to day consumer applications has resulted in the municipal solid waste, an ever growing fraction of plastic materials which were used for a short time and then discarded. There is, therefore a growing need to find alternative uses of reclaimed plastic bag waste to lengthen the usage time of the plastic material and thereby save the degrading environment. The concept of reinforcing soil masses with strips of plastic cover may be relatively, a new development. In contrast, the use of random-materials as reinforcement for soil is probably not older than written history, but only sparsely represented

The objective of this project is to analyse the effect of inclusion of plastic fibers in soil on the stability of soil in a cost effective manner. The four different replacement percentages of plastic fibers (0.25%,0.5%, 1%, 1.5%) will be tested.

III. METHODOLOGY

A. *Component Materials:*

Component materials were:

- Soil
- Plastic Fiber

1) Soil:

The clayey soil used for the study was collected from Kalathipadi in Kottayam district. Clayey soils are inorganic clays of medium to high compressibility and form a major soil group in India. They are characterized by high shrinkage and swelling properties. Because of its high swelling and shrinkage characteristics, the clayey soils have been a challenge to the civil engineers. The clayey soil is very hard when dry, but loses its strength completely when in wet condition. Rich proportion of montmorillonite is found in clayey soil from mineralogical analysis. High percentage of montmorillonite renders high degree of expansiveness. This property results cracks in soil without any warning. These cracks may sometimes extent to severe limits. So building to be founded on this soil may suffer severe damage with the change of atmospheric conditions.

2) Plastic fiber:

Plastic fibers were obtained from waste plastic cover (milk and curd packets) . After proper cleaning and air drying, the plastic covers were shred into fibers each of average thickness of 2mm. These plastic covers are usually considered to be waste materials.

IV. RESULTS

A. *Soil Characteristics:*

Test was conducted to find various characteristics of the soil sample. The results obtained are tabulated in Table 4.1.

Table - 4.1
Results of Classification tests

Natural Moisture Content	*52.5%*
Specific Gravity	*1.825*
Hydrometer Analysis	*Silty clay*
Optimum Moisture Content	*32.43%*
Maximum Dry Density	*1.295*
Compressive Strength	*0.068 N/mm^2*

B. *Engineering Property Tests:*

Tests were conducted on untreated sample and Samples with0.25%, 0.5%, 1% and 1.5% replacement of soil with plastic fibers. The tests were conducted as per the procedure specified in IS 2720 part VII- 1980.the standard proctor test and unconfined compressive tests were conducted.the resukts from the two tests are given below

Table - 4.2
Results from Proctor Test Conducted

Soil sample	*OMC (%)*	*MDD(g/cm^3)*
Untreated soil	*32.43*	*1.295*

99.75%soil + 0.25% plastic	*25.3*	*1.33*
99.5%soil + 0.5% plastic	*29.35*	*1.38*
99%soil + 1% plastic	*24.08*	*1.34*
98.5%soil + 1.5% plastic	*33.12*	*1.32*

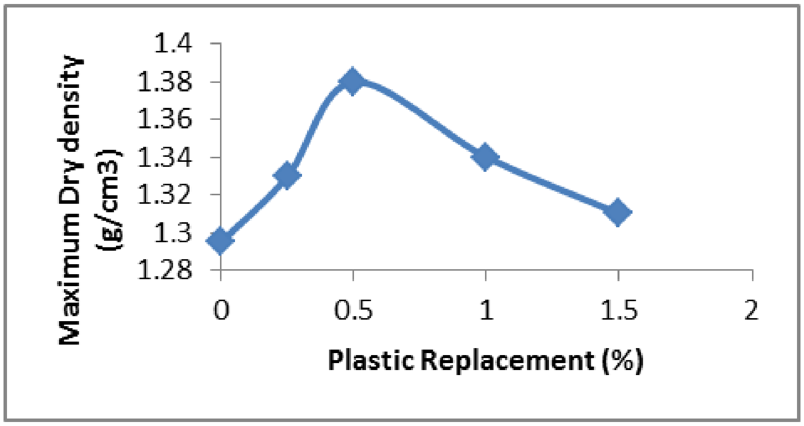

Fig. 1: Proctor Results

Fig.1 shows the variation in the values of Maximum Dry Density for untreated soil sample, and treated soil samples with 0.5, 1, 1.5% plastic replacement. It can be seen that the Maximum Dry Density increased from 1.29 for untreated soil sample to 1.383 for soil sample with 0.5% plastic replacement. But thereafter the value decreases. The increase in the Maximum Dry Density is due to the decrease in the number of voids due to the addition of plastic. This will enhance compaction which in turns reduce the OMC and increase the Maximum dry Density.

Table 4.3
Results from UCC Tests Conducted

Soil Sample	*Compressive strength (N/mm^2)*
Untreated soil	*0.0255*
99.75%soil + 0.25% Plastic	*0.0383*
99.5% soil + .5% Plastic	*0.050*
99% soil + 1% Plastic	*0.042*
98.5% soil + 1.5% Plastic	*0.0152*

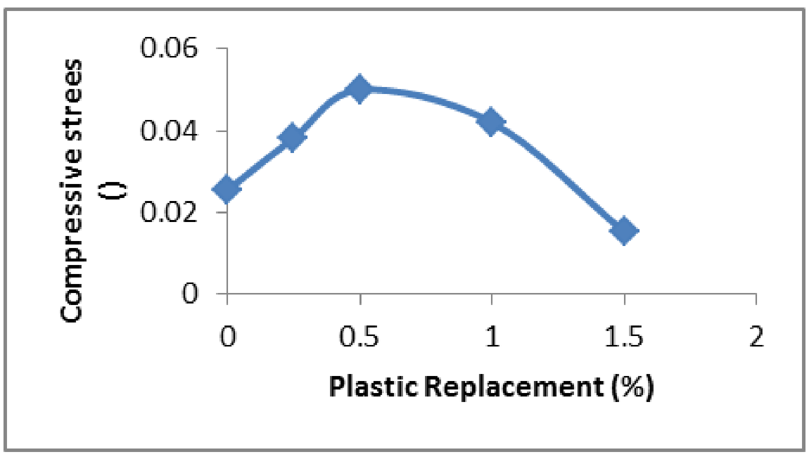

Fig. 2: UCC RESULTS

The Fig.2 shows the variation in the values of Unconfined Compressive Strength of the untreated soil sample and soil samples which are treated with 0.5, 1, and 1.5% plastic. The unconfined compressive strength increases from 0.0255 N/mm^2 for untreated soil sample to 0.050 N/mm^2 for soil sample treated with 0.5% plastic. The strength of the sample then decreases with further addition of plastic. The maximum value in strength is achieved corresponding to optimum plastic content ie; 0.5% plastic content. With the addition of plastic to the sample of soil there is an increase in the cohesion of soil which leads to increase in the unconfined compressive strength of the soil. But further increase in the plastic content leads to decrease in the cohesion and thereby decrease in the strength. Also the shear strength of the soil which is directly related to the cohesion shows a similar pattern such that a maximum value is obtained at 0.5% plastic replacement and then it decreases.

V. CONCLUSION

This project is focused on the review of performance of plastic fiber as a soil stabilization material. The study suggests that if plastic fiber if properly mixed and applied, can be used as a great soil stabilization technique .On the basis of this project the following results were obtained.

1) The replacement of 0.5% plastic fibers to the expansive clayey soil reduce its OMC and increased the Maximum Dry Density.
2) The unconfined compressive strength of the soil was found to be increased for 0.5%.
3) With 1% replacement it was observed that the MDD & UCC was less than the 0.5% replacement but was greater than the untreated soil.
4) Further increase in the plastic replacement showed decrease in the MDD and the Unconfined Compressive Strength of the soil.
5) Based on the non-problematic soil criteria, the optimum percentage of plastic is recommended as 0.5% which will improve the engineering properties of the silty clay.
6) The increase in the Maximum Dry Density of the soil is due to the decrease in the number of voids with the addition of plastic which leads to effective compaction and also increase in the cohesion.

The main advantage of using plastic fiber is proven to be economical as it is non useful waste and free of cost. It also eradicates the disposal problem of plastic waste. Further research in this field may shed light on application of plastic material for stabilization of soil.

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