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STABILIZATION OF BLACK COTTON SOIL BY USING WASTE FIBRE AND LIME

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Abstract

Soil stabilization has been introduced into the field geotechnical engineering for many years in order to improve the property of ground soil in specific it is the one of the most popular techniques used for the improvement of poor soil. Further, soil stabilization causes significant improvement in shear strength, bearing capacity, as well as economy. The main objective of this study is to investigate the use of waste fibre materials and lime in geotechnical applications and to evaluate the effect of waste polypropylene fibre and lime on shear strength of unsaturated soil by carrying out direct shear test and unconfined compression tests on two different soil sample the result obtained are compared for the two sample and inferences are drawn towards the usability and effectiveness of fibre reinforcement and lime as a replacement for deep foundation or raft foundation ,as cost effective approach.

Keywords:-*Waste fibre material**, California Bearing ratio (CBR),unconfined compressive strength(UCS)*

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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 soil, we need to have proper knowledge about their properties and factor which affect their behaviour work. The process of soil stabilization helps to achieve the required properties in soil needed for the construction work.

Keeping in mind the large geographical area of India (3,287,240 sq.km) and population of India (125 million approximate) the vast network of structure and roads are required. The land available for construction is very less because of increasing urbanization and modernization. Everywhere land is being utilize for various structure from an ordinary house to sky scrapers, from bridges to airport and from village road to highway or expressway. Soil being cheapest and readily available construction material, has been popular with the Civil Engineers, even though it being poor properties.

From the beginning of construction work, the necessity of enhancing soil properties has come to light. Ancient civilization of the Chinese, Romans and Incas utilized various method to improve soil strength etc., some thus method so effective that their building and road still exist.

In India, the modern era of soil stabilization began in early 1970‟s , with a general shortage of petroleum and aggregates , becomes necessary for the engineers to look at means to improve soil other than replacing the poor soil at the building site. Soil stabilization was use but due to the use of obsolete methods and also due to absence of proper technique, Soil Stabilization lost favour. In recent time, with the increase in demand for infrastructure, row materials and fuel, Soil Stabilization 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.

Here, in this project, Soil Stabilization has been done with the help of randomly distributed fibres obtained from waste materials. The improvement in the shear strength parameters has been stressed upon and comparative studies have been carried out using different method of shear resistance measurement.

For all he above reason, expansive are generally poor materials for construction so to improve the soil properties stabilization or reinforcement of soil is done. Soil reinforcement is defined as a technique to improve the engineering characteristics of soils. In this way, using natural fibres to reinforced soil is an old an ancient idea .

OBJECTIVE

1. The prime objective of soil stabilization is to be improving the California bearing ratio of in-situ soil by 4 to 6 times. The other prime objective of soil stabilization is to improve on site materials to create solid and strong sub base and base course. In certain regions of the world, typically developing countries

and now more frequently in developed countries, soil Stabilization is being used to construct the entire road.

2. Originally, soil stabilization done by utilizing the bending properties of clay soil cement-product such as soil cement ,and /or utilizing the rammed earth technique (soil compaction) and lime.
3. Improvement of bearing capacity of black cotton soil on addition of lime.
4. Variation of strength of soil at different water content.
5. Effect of lime on CBR value of soil.
6. Effect of lime on compressive strength of soil.

EXPRIMENTAL INVESTIGATION

Scope of Work

a. The experimental work consist of the following work.
b. Specific gravity of soil.
c. Determination of soil index properties (Atterberg Limits)
   i. Liquid limit by casagrandes apparatus
   ii. Plastic limit
d. Particle size distribution by sieve analysis
e. Determination of maximum dry density (MDD) and the corresponding optimum moisture content (OMC) of the soil by Proctor compaction test.
f. Preparation of reinforced soil samples.
g. Determination of shear strength by
   i. Direct shear test (DST)
   ii. Unconfined compression test (UCS).

Materials

a. Soil sample-1
b. Reinforcement: Short PP (polypropylene) fibre

Fig. 1: Polypropylene fibre

3)STEPS FOR MIXING OF FIBRES TO SOIL

All the soil samples are compacted at their respective maximum dry density (MDD) optimum moisture content (OMC), corresponding to the standard proctor compaction test.

a. Content of fibre in the soil are here decided by the following equation.

Where, pf = Ratio of the fibre content

Wf = Weight of the fibre

W = Weight of the air dried soil

b. The different values adopted in the present study for the percentage of fibre reinforcement are 0, 0.05, 0.15 and 0.25.
c. The preparation of samples , if fibre is not used then, the air dried soil was mixed with an amount of water that depends on the OMC of the soil if fibre reinforcement was used, the adopted content of fibres was the first mixed with the air dried soil in small increments by hands, making sure that all the fibres were mixed thoroughly, so that a fairly homogeneous mixture is obtained, and then required water was added.

Fig:- 2 Lime

Table1. Index and strength parameters of pp-fibre

Behavior parameters	Values
Fiber type	Single fiber
Unit weight	0.91 g/cm3
Average diameter	0.034 mm
Average length	12 mm
Breaking tensile strength	350 MPa
Modulus of elasticity	3500 MPa
Fusion point	1650C
Burning point	5900C
Acid and alkali resistance	Very good
Dispensability	Excellent

A) Specific gravity of the Soil

Specific gravity of substance denotes the number of times that substance is heavier than water. In simpler words we can define it as the ratio between the mass of any substance of definite volume divided by mass of equal volume of water. In case of soil, specific gravity is the number of times the soil solid are heavier than equal volume of water.

W1=Weight of bottle in gms.

W2=weight of bottle + Dry soil in gms

W3=weight of bottle + soil+ water

W4=weight of bottle +water

Specific gravity is always measured in room temperature and reported to the nearest 0.1

B) Plastic Limit

This is determined by rolling out soil till its diameter reaches approximately 3mm 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,

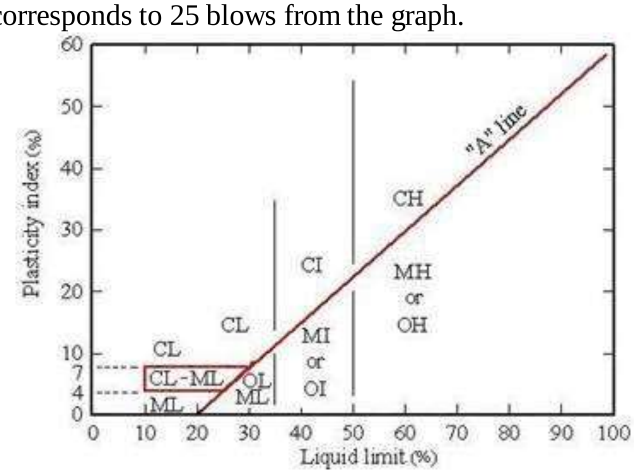
Ip =Wl –Wp

Wl = Liqid limit

Wp = Plastic limit

C) Liquid Limit

The casagrande tools cuts a groove of size 2 mm wide at the bottom and 11 mm wide at the top and 8mm high. The number of blows use 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.



D) Particle size distribution

The result from the sieve analysis of the soil when plotted on semi log graph with particle diameter or the sieve size as the abscissa with a 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 particle lie. The ratio of D10 and D60 gives the uniformity coefficient (Cu) which in term is measured of the particle size range.

E) Proctor compaction test

This experiment gives a clear relationship between the dry density of the soil and the moisture content of the soil. The experimental setup consists of (i) cylindrical metal mould (internal diameter- 10.15 cm and internal height-11.7 cm), (ii) detachable base plate, (iii) collar (5 cm effective height), (iv) rammer (2.5 kg). Compaction process helps in increasing the bulk density by driving out the air from the voids. The theory used in the experiment is that for any compactive effort, the dry density depends upon the moisture content in the soil. The maximum dry density (MDD) is achieved when the soil is compacted at relatively high moisture content and almost all the air is driven out, this moisture content is called optimum moisture content (OMC). After plotting the data from the experiment with water content as the abscissa and dry density as the ordinate, we can obtain the OMC and MDD.

F) Direct shear test

This test is used to find out the cohesion (c) and the angle of internal friction (υ) 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 υ. 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. The equation goes as follow,

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

G) 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.

qu= load/corrected area (A‟‟)

qu- compressive stress

A‟‟= cross-sectional area/ (1- ε)

Preparation of samples:-

Following steps are carried out while mixing the fiber to the soil

a. All the soil samples are compacted at their respective maximum dry density (MDD) and optimum moisture content (OMC), corresponding to the standard proctor compaction tests

b. Content of fiber in the soils is herein decided by the following equation:

Pf =Wf /W

Where, ρf= ratio of fiber content

Wf = weight of the fiber

W = weight of the air-dried soil

i. The different values adopted in the present study for the percentage of fiber reinforcement are 0, 0.05, 0.15, and 0.25.

ii. In the preparation of samples, if fiber is not used then, the air-dried soil was mixed with an amount of water that depends on the OMC of the soil.

iii. If fiber reinforcement was used, the adopted content of fibers was first mixed into the air-dried soil in small increments by hand, making sure that all the fibers were mixed thoroughly, so that a fairly homogenous mixture is obtained, and then the required water was added.

RESULT AND DISCUSSION

The test result are summarised in table .the variation in the optimum moisture content , maximum dry density, California bearing ratio, unconfined compressive strength and differential free index are shown in figure.

Table : summery of result

	Sample01	Sample02	Sample03
Specific Gravity Of Soil Without Fiber	3.1315	2.25	3.6042
Specific Gravity Of Soil With Fiber	3.64	2.355	3.6295
Liquid Limit Of Soil Without Fiber	41.33 %	48.15%	46.11%
Liquid Limit Of Soil With Fiber	44.89%	38%	42.40%
Plastic Limit Of Soil Without Fiber	29.68%	30.47%	30.42%
Plastic Limit Of Soil With Fiber	23.35%	29.04%	28.03%
Shrinkage Limit Of Soil Without Fiber	4.029	3.77	3.74
Shrinkage Limit Of Soil With Fiber (Ppf)	6.65	7.08	6.26

CONCLUSION

On the basis of present experimental study, the following conclusions are 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 (illustrated in figure- 25). The increase in the internal angle of friction (υ) was found to be 0.8%, 0.31% and 0. 47% respectively (illustrated in figure- 27). Since the net increase in the values of c and υ 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 (illustrated in figure- 29). This increment is not substantial and applying it for soils similar to soil sample- 1 is not effective.

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