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RESEARCH ARTICLE

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A LABORATORY STUDY ON IMPROVING PROPERTIES OF CLAY SOIL USING PLASTIC WASTE

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ABSTRACT

Vast areas covered with thick soil deposits having very low shear strength and high compressibility. These soils are generally weak and possess high deformation values in nature. soft soils are generally labelled as 'problematic' because they have poor resistance to deformation, low permeability and limited bearing capacity. Due to the poor engineering characteristics of these soil deposits, they pose several foundation problems to various coastal structures.

In any developing country infrastructure, transportation and communication facilities play a major role for the development. Majority of the population in India depends on road –based transport.

This report presents the various tests conducted on fibre reinforced soil with varying fibre content their results are analysed such that it can be used in the fields. Therefore, it is of utmost importance considering the design and construction methodology to maintain and improve the performance of such pavements. In this paper, plastic such as shopping bags is used to as a reinforcement to perform the CBR studies while mixing with soil for improving engineering performance of sub grade soil. Plastic strips obtained from waste plastic were mixed randomly with the soil. A series of California Bearing Ratio (CBR) and unconfined compressive strength (UCS) tests were carried out on randomly reinforced soil by varying percentage of plastic strips with different lengths and proportions. Results of CBR and UCS tests demonstrated that inclusion of waste plastic strips in soil with appropriate amounts improved strength and deformation behaviour of sub grade soils substantially. The proposed technique can be used to advantage in embankment/road construction, industrial yards etc.

INTRODUCTION

Stabilization of soil 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 or dust formation in the soils the main aim is the creation of soil material or system that will hold under the design use condition and for the designed life of the Engineering project. The success of Soil Stabilization depends on soil testing. Various methods are employed to stabilize soil and the methods should be verified in the lab with the soil material before applying on the Field.

I. STABILIZATION WITH PLASTIC WASTE

Waste plastic is one such which is commonly used for shopping bags, storage and marketing for various purposes due to its most advantage character of less volume and weight . Most of these plastic are specially made for spot use, having short life span and are being discarded immediately after use. Though at many places waste plastics are being collected for recycling or reuse, however; the secondary markets for reclaimed plastics have not developed as recycling program. Therefore, the quantity of plastics that is being currently reused or recycled is only a fraction of the total volume produced every year. The estimated municipal solid waste production in India up to the year 2000 was of the order of 39 million tons per year. From this plastics constitute around 4% of the total waste. The principle of resisting action of strips is visualized in fig(1) .

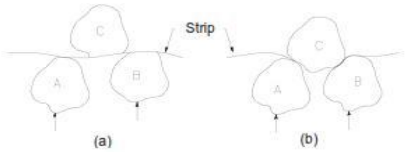

Fig.1. **Schematic** diagram showing position of strip (a) Before and (b) After slippage between soil and strip

With the few reasons cited above, it is very important to re-utilize these plastic wastes. Therefore the investigations and attempts has been made to demonstrate the potential of reclaimed plastic wastes as soil reinforcement for improving the sub grade soils. In this stabilization we used high density poly ethylene (HDPE) as a stabilizer. These stripes were cut to dimension of 15mm width and 30 mm height.

A. Scope Of The Work

With the few reasons cited above, it is very important to re-utilize these plastic wastes. Therefore the investigations and attempts has been made to demonstrate the potential of reclaimed plastic wastes as soil reinforcement for improving the sub grade soils. In this stabilization we used high density poly ethylene (HDPE) as a stabilizer. These stripes were cut to dimension of 15mm width and 30 mm height.

B. Sequence Of The Work

- Determination of soil index properties.Liquid limit by casagrande's apparatus and Plastic limit.
- Particle size distribution by wet sieve analysis.
- Determination of the maximum dry density (MMD) and corresponding optimum moisture content (OMC) of the soil by proctor compaction test.
- Preparation of reinforced soil samples.
- Determination of the strength by CBR test.
- Determination of shear strength by unconfined compression test.

II. LITERATURE

Rao.G.V and Dutta R.K[1] ,(2004)"Ground improvement with plastic waste "Proceeding, 5th International Conference on Ground under the search of many investigators have conducted the studies on fiber-reinforced materials. The inclusion of discrete fibers increased both the cohesion and angle of internal friction of the specimens . The improvement of the engineering properties due to the inclusion of discrete fibers was determined to be a function of a variety of parameters including fiber type, fiber length, aspect ratios, fiber content, orientation, and soil properties. The peak strength reportedly increased with increasing fiber content and length up to a limiting amount of each beyond which no additional benefits were observed.

A.K. Choudhary, J.N. Jha and K.S. Gill [2], studied on the feasibility of reinforcing soil with strips of reclaimed HDPE. Strips of HDPE were mixed with local sand and tested to determine CBR values and secant modulus. The tests show that reinforcing sand with waste HDPE strips enhances its resistance to deformation and its strength.

Pragyan Bhattarai, A. V. A Bharat Kumar, K. Santosh, T. C. Manikanta& K.Tejeswini[3] suggested that expensive methods for stabilization can be replaced by the reinforcement with plastic strips which will make the construction process economical and also make the proper arrangement of plastic waste conserving the various component of the environment. Megnath Neopaney, Ugyen, Kezang Wangchuk, Sherub Tenzin infered that base

course thickness can be significantly reduced if waste plastic strip is as soil stabilizing agent for sub-grade material. They got the optimum result when 0.5% is added to it. According to E.I. Atuanya, W.T. Aborisade and N.A. Nwogu, the result of the physico-chemical parameters of the soil revealed that the addition of plastic granules to the soil resulted to increase in the bulk density of the soil. According to Muntohar, A. S, the clay soil was stabilized with lime and rice husk ash mixtures. The effect of the fiber length and content on the compressive and split tensile strength was investigated.

Al-Refeai, T[4], 1991 ,Behaviour of granular soils reinforced with discrete randomly oriented inclusions. soils and their related behaviour has always been the subject of many studies. Recent researches show some interests in investigation of inclusion of randomly distributed fiber in soil. This study focuses on effect of fiber inclusion on the strength and other parameters of clayey sand composite material.

Gray, D.H., Al-Refeai, T[5], 1986. Behaviour of fabric versus fiber-reinforced sand. Journal of Geotechnical Engineering 112 (8), 804–820.This study focuses on effect of fiber inclusion on the strength and other parameters of clayey sand composite material. First part of this study is related to effective parameters on strength of the clayey sand composite with using natural fiber and plastic fiber and different fiber contents .

III. METHODOLOGY

A. *General*

- Properties of the soil and type of soil was determined by using atterberg limits and sieve analysis and the strength of soil mixed with plastic waste of varying plastic waste strips was found.
- California Bearing Ratio test (CBR) which is done to the sample which is kept in soaked condition for 4 days and Unconfined Compression Tests for soil reinforced with plastic waste were conducted and there results were compared.

B. *Material Properties*

The soil used is typical soft clay soil collected at a depth of 1.0m to 2.0 m from ground level near Kakinada. All tests were conducted as per IS specifications.

S. No	**Property**	**Properties**
1.	Liquid Limit (%) Plastic Limit (%) Plasticity Index (%)	41 25 16
2.	IS Classification	CI
3.	Free Swell (%)	50

The plastic used is High Density Polyethylene (HDPE), offers excellent impact resistance, light weight, low moisture absorption, high tensile strength. It is also non-toxic and non-staining and meets FDA and USDA certification for food. The properties of HDPE are shown below:

- Density = 0.95(gm/cm3)
- Tensile Strength = 4,600(Psi)
- Flexural modulus = 200,000(Psi)
- Izod notch test = 3 (ft-lb/in)
- Max operating temp = 180^{o}f

C. *Tests Conducted*

- The liquid limit and plastic limit of clay soil were determined as per IS:2720(Part-5)-1985 and IS:2720(part-6)-1972 respectively.
- The Optimum moisture content(OMC) and Maximum dry density (MDD) are determined by compaction test as per IS:2720(Part VIII)-1983.The test was carried out at 0.5%,0.75% and 1% proportion of plastic waste and corresponding OMC and MDD is figured out from graph.
- Free swell index of soil is determined as per IS:2720(Part XL)-1977 to found the increase in volume of soil without any external constraint when subjected to submergence in water.
- California bearing ratio test were conducted as per IS:2720(part-16)-1979 on all the combinations, at the end of the curing period. Samples were prepared by compacting different mixes to the MDD of the soil. The plastic waste of 0.5%, 0.75%

and 1% was added to the air dry soil and mixture was thoroughly mixed.

- The unconfined compressive strength of soil is determined as per IS:2720(part-10)-1991.The untreated and treated soil sample with 0.5%, 0.75% and 1% plastic waste are prepared and loaded till they fails due to shear.

D. Plastic strips and plastic mixed with clay soil

Fig : 2. Plastic Waste cut into strips of size(15*30)mm

Fig : 3 Plastic Waste mixed with clay soil

IV. RESULT

A. General

The above mentioned tests were conducted in order by using compaction method the O.M.C and M.D.D values were found for each varying plastic, by using the obtained O.M.C and M.D.D, California Bearing Ratio test and Unconfined Compression Tests were carried the results were presented as graphs below.

i. Compaction values

O.M.C and M.D.D values of clays soil mixed with varying percentage of Plastic Waste.

TABLE I: O.M.C & M.D.D values for clay soil of varying plastic waste

S.No	Percentage Of Plastic Waste	O.M.C	M.D.D
1	0.0%	18.5	1.46
2	0.50%	19.1	1.43
3	0.75%	20.5	1.41
4	1.00%	22	1.4

ii. C.B.R values for clay soil of varying plastic waste.

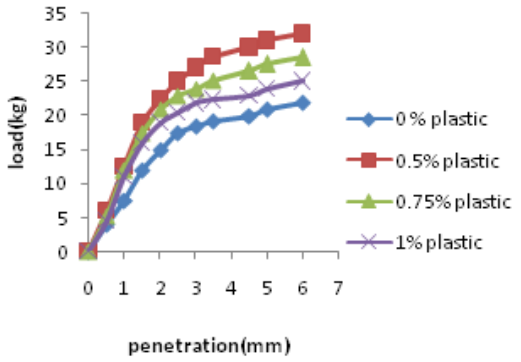

Fig :4 penetration vs load for clay soil of varying plastic percentage .

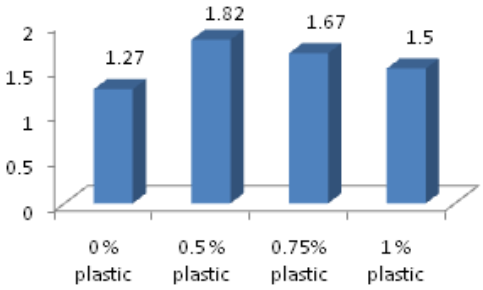

Fig :5 C.B.R values for soil mixed with varying percentage shown in bar graph

iii. *U.C.S values for clay soil of varying plastic waste*

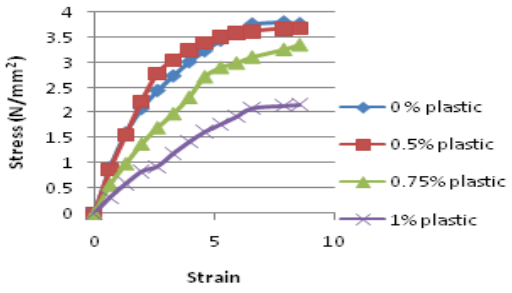

Fig :6 strain vs stress for clay soil mixed with varying percentage .

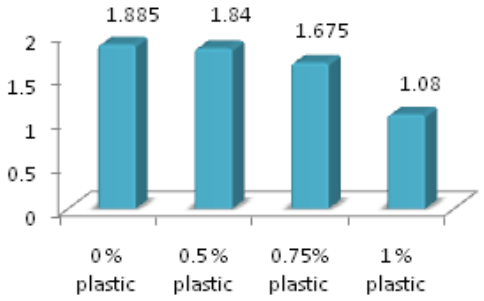

Fig :7 ucs values for clay soil mixed with varying percentage shown in bar graph .

VI. DISCUSSIONS

In the present study the optimum value of CBR is obtained at o.5 % plastic waste. The U.C.S value decreases with increase in plastic waste this was caused as U.C.S test is carried out in fields but we have done in laboratory by preparing sample where there may be uneven distribution of plastic in the sample , overall the strength of soil clay soils can be increased by adding plastic waste.

V. CONCLUSIONS

1. It is observed from the laboratory test results of compaction that the density of the untreated clay soil is 1.46 g/cc.
2. The density of the clay soil treated with 0.5% plastic waste is decreased by 2%.
3. The density of the clay soil treated with 0.75% plastic waste is decreased by 3.42%.
4. The density of the clay soil treated with 1% plastic waste is decreased by 4.1%.
5. It is observed that the CBR value of the untreated clay soil is 1.27%.
6. It is observed that the CBR value of the clay soil treated with 0.5% plastic waste has been increased by 30.21%.
7. It is observed that the CBR value of the clay soil treated with 0.75% plastic waste has been increased by 23.95%.
8. It is observed that the CBR value of the clay soil treated with 1% plastic waste has been increased by 15.33%.
9. The CBR value of clay soil is optimum at addition of 0.5% plastic waste and was gradually decreased.
10. It is observed that the shear strength value of untreated clay soil is 1.875 N/mm^2.
11. It is observed that the shear strength value of clay soil treated with 0.5% plastic waste is decreased by 2.12%.
12. It is observed that the shear strength value of clay soil treated with 0.75% plastic waste is decreased by 11.17%.
13. It is observed that the shear strength value of clay soil treated with 1% plastic waste is decreased by 42.55%.

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