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Utilization of Plastic and Fly Ash as Soil Stabilizers

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Abstract: This paper present the effect of plastic waste as a strips on the strength of Black cotton soil and fly ash mixtureand the results are presented in term of compressive strength, shear strength, California bearing ratio CBR) characteristics. The different percentage of plastic waste0.5%, 1.0%, by dry weight of 10mm length and 5 mm width) Owing to the fact that fly ash possess no plastic property, plasticity index (P.I.) of clay-plastic strip-fly ash mixes show a decrease in value with increasing fly ash content. In conclusion, addition of plastic strip and fly ash results in decrease in plasticity of the expansive soil, and increase in workability by changing its grain size and colloidal reaction. Tested under both soaked and un-soaked conditions, the CBR values of clay with plastic strip and fly ash mixes were observed. Analysis of the formerly found result exposes the potential of plastic strip and fly ash as an additive that could be used for improving the engineering properties of expansive soils.

Keywords*:* Soil Stabilizers, black cotton soil, Unconfined Compression Test, California bearing ratio (CBR) test.

I. INTRODUCTION

Soil Stabilization is the process of blending and mixing materials with soil to improve certain properties of the soil. The process may include the blending of soils to achieve a desired gradation or the mixing of commercially available additives that may alter the gradation, texture or plasticity, or act as a binder for cementation of the soil. The long-term performance of any construction project depends on the soundness of the under-laying soils. Unstable soil scan creates significant problems for pavements. Lack of adequate road networks to cater to the increased demand and increase distress in road leading to frequent maintenance have always been big problem in our country. Evolving new construction materials to suit various traffic and site conditions for economic and safe design is a challenging task in road construction. Effective utilization of local weak soils by imparting additional strength using stabilization materials enables reduction in construction cost and improved performance for roads. Fly ash is the residue produced from thermal power plants. Its composition basically depends on the type of coal which is fused during combustion in the power plant. It is a pozzolanic material. Nowadays fly ash has found its application in many areas like manufacturing ofcement and bricks, land filling, construction of roads and embankments etc. and is thus moved from the category of—hazardous waste to useful waste material in the year 2009 by the government of India. Similarly, a large percentage of tile waste is produced in the country arising in theneed of its proper disposal. Stabilization of poor soil is a rapidly emerging area which can be used for proper utilization of waste material.

The Properties of a soil are very uncertain when it is subjected to variable moisture. It shows huge volumetric change, when exposed to dry and wet conditions. This is due to presence of active clay minerals. When water occupies large space in the voids of soil the strength of soil changes. These changes create challenges for civil engineers doing work on site especially while constructing foundations. Though black cotton soil is unfit for infrastructural development, they are useful to protect environment and waste disposal. For the construction of any kind of structure resting on weak soil, various available methods are used to improve the bearing capacity and reduce the settlement of soils. One of the methods is using reinforcement. The concept of reinforcement of soil by using fibers was developed in the 19th century. The main objective of reinforcing the soil was to upgrade its properties. The reinforcing material introduced in the soils alters the strength and deformation characteristics of the soil. Plastic is considered as one of the best inventions in many aspects of life. The amount of plastic waste is increasing year by year. Due to this the need for plastic waste management has increased so that it can be used as soil stabilizer and in other ground improvement techniques as it behaves like reinforcing material. Plastics waste is of two types: Pre-use plastic (production scrap) and post-use plastic. In India around 25,940 tonnes of plastic waste is generated in a day (t/day), according to a report made by the Central Pollution Control Board (CPCB) that studied 60 major cities. These cities together produced 4059 T/day. Delhi takes first position in generating maximum plastic waste followed by Chennai, Mumbai, Bangalore and Hyderabad. A graph indicating the major cities producing plastic waste is shown below. As plastic is non decomposable material or has very slow rate of decomposition so it will

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accumulate in the environment and adversely affects the ecosystem. Plastic which acts as pollutants are divided into two types according to their sizes. These are micro and macro pollutants. As plastic are economical and durable than other materials so their production by humans are quite high. The chemical structure of plastic makes them resistant to many natural process of decomposition as a result they are almost non decomposable material.

II. LITERATURE REVIEW

Palak Chopra, G.S Bath , Amanpreet Singh Virk [1] In this study, Fly ash, by-product of thermal power plant, is used for stabilization of expansive soils. The disposal of Fly Ash is a big problem for environment, so it should be used for good cause. In this research paper, fly ash is added in the clayey soil in the proportion of 5%, 10%, 15%, 20% and 25% by weight of soil and the properties are compared with parent soil. The properties studied are liquid limit, plastic limit, plasticity index, California bearing ratio (CBR) and unconfined compressive strength. With the increase in Fly ash OMC is decreased from 20.75% 17.18%, whereas MDD of the soil has shown an increasing path from 1.614 gm/cc to 1.693 gm/cc

Saket Dixit [2]. In this study different types of waste plastic were randomly mixed with the soil, then a series of California Bearing Ratio (CBR) tests were conducted to evaluate the strength of subgrade soil. High density polyethylene (HDPE), Low density polyethylene (LDPE) and Polypropylene (PP) at various percentages were used for improving soil strength. Results from the CBR tests established that addition of these materials in subgrade soil gives efficient strength to subgrade soil. It was observed that the CBR value increases with increase in fiber content up to a certain percentage but decreases with further addition of waste plastic content. The pavement sections has been designed with the modified subgrade using HDPE, LDPE & PP and the critical strain values at the top of the subgrade and at the bottom of the bituminous layer has been analyzed and compared with the allowable values as per IRC: 37-2012 for the traffic loading of 150 msa for the four-lane divided state highway project. The reduction in the crust thickness and saving in the project cost has been compared for the different subgrade with different waste plastics and by varying plastic contents.

Vijay Kumar Patidar, Dr. Suneet Kaur [3]. Soil stabilization alters the physical properties of soil to improve its strength, durability, or other qualities to meet the engineering requirements. It can be achieved by adding suitable admixtures like cement, lime and waste material like fly ash, gypsum etc or by other suitable stabilization methods. the cost of adding these additives has tremendously increased in past few years; there is need for the development of other kinds of soil additive such as plastic, bamboo etc, and these new techniques of soil stabilization using plastic waste which can be effectively used to solve the challenges of society, thereby reducing the amount of waste plastic material.

Wajid Ali Butt, Karan Gupta and J. N. Jha [4]. This experimental study has revealed that the addition of SDA results in a significant increase in CBR and unconfined compressive strength. Furthermore, the values of CBR obtained are within the limits recommended by the Asphalt Institute for Highway sub-base and sub-grade. Thus from the present study it is concluded that SDA, an industrial waste, is a cheap satisfactory stabilizing agent for sub-base and base course in clayey fills; although its performance can be improved by combining it with other bonding materials such as lime, and becomes an alternatives use of industrial waste to reduce the construction cost of road particularly in the rural areas of the country

Dr. A.I. Dhatrak [5] after reviewing performance of plastic waste mixed soil as a geotechnical material, it was observed that for construction of flexible pavement to improve the sub grade soil of pavement using waste plastic bottles chips is an alternative method. In his paper a series of experiments are done on soil mixed with different percentages of plastic (0.5%, 1%, 1.5%, 2 % & 2.5%) to calculate CBR. based on experiments it is concluded that by using plastic waste strips the soil strength is improving and can be used as sub grade. It is economical and eco-friendly method to dispose of waste plastic because there is scarcity of good quality soil for embankments and fills.

Akshat Malhotra and Hadi Ghasemain [6] studied the effect of HDPE plastic waste on the UCS of soil. In a proportion of 1.5%, 3%, 4.5% and 6% of the weight of dry soil, HDPE plastic (40 micron) waste was added. They concluded that the UCS of black cotton soil increased in addition of plastic waste. When 4.5 % plastic waste mixed with soil strength obtained was 287.32KN/m2 which is maximum because for natural soil it was 71.35KN/m2.

Babita Singh, Amrendra Kumar and Ravi Kumar Sharma [7], in this paper an attempt has been made in the direction of improving the lacking geotechnical properties of locally available clayey soil by adding admixtures i.e. sand, fly ash and tile waste in suitable proportion. The suitable proportion in which the admixtures are to be added in the clay is decided with the help of proctor compaction test to obtain the Optimum mixes. These optimum mixes obtained through the experimental investigation carried were further checked for strength characteristics through California bearing ratio test. A considerable improvement in the CBR value was obtained for these optimum mixes in comparison to that of pure clay. The results of experimental investigation reveals that soil- sand::70:30,soil:sand:flyash::63:27:10 and soil:sand:fly ash: tile waste::63:27:10:9 are the best optimum mixes on the basis of compaction characteristics and for every optimum mix CBR value shows an increasing trend. Basic purpose of this study is to use the waste materials (river sand, fly ash and tile waste) as additives to solve the problem of disposing them and producing a cheaper construction material. Also, the gainful effects of these waste materials when used in a composite form on the geotechnicalproperties of locally available clayey soil can be visualized from this study.

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Murat Olgun [8] An experimental investigation was conducted to evaluate the effects of polypropylene fiber inclusions on the geotechnical characteristics of a clayey soil that was chemically stabilized with cement and fly ash. For all stabilized soils, cement and fly ash were added at 8% and 30%, respectively. Reinforced stabilized soil specimens were prepared at four different percentages of fiber content (0.25%, 0.50%, 0.75%, 1.0%) and three different fibers lengths (6 mm, 12 mm, 20 mm). Unconfined compressive and split tensile strength tests were carried out after 7- and 28-day curing periods. The volume change characteristics of the reinforced stabilized soil were determined using shrinkage limit and crack reduction values. The interactions between the fiber surface and the stabilized soil were analyzed by means of scanning electron microscopy.

III. MATERIAL USED

Soil: - Nearly 100 Kg of black cotton soil was collected from Kota Then the soil was sieved through 4.75mm sieve to remove the gravel fraction. The soil is classified as Intermediate compressible clay, CI, as per IS: 1498 (1970). The physical properties of soil are reported in Table 1.

Table 1 Physical Properties of soil

S. No.	Parameters	Result
1.	Modified Compaction TestMDD (gm/cc) OMC (%)	1.73 17.69
2.	Liquid Limit (%)	48.38
3.	Plastic Limit (%)	23.59
4.	Plasticity Index (%)	24.79
5.	Specific Gravity	2.74
6.	Indian Soil Classification	CI

Waste Plastic

Waste Plastic have been obtained from "Rajaram Sharma Industry" from goner fatal Jaipur. The Plastic strips are mixed in percentage of 0.5%, 1.0%, by dry weight of soil.

Fly Ash

Fly ash was collected from the market the fly ash was oven dried and was passed through 300- micron sieve. The fly ash was mixed with parent soil in same percentage (5%). The chemical properties of Fly ash are given in Table 2.

Table 2 Chemical Properties of Fly Ash

Sr. No.	Parameter	% age
1	SiO2	56.33
2	Al2O3	23.45
3	Fe2O3	5.19
4	TiO2	0.94
5	Cao	3.47
6	MgO	0.63
7	SO3	0.44
8	K2O	1.30

IV. EXPERIMENTAL PROCEDURE

Following are the tests which have been carried out in laboratory: -

Characteristics Tests

- Moisture Content Determination.
- Atterberg Limits Determination.
- Specific Gravity Test by Pycnometer.

Strength Tests

- Heavy Compaction Test - IS : 2720 (Part 8) - 1983

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- Unconfined Compression Test - IS : 2720 (Part 10)- 1991
- California bearing ratio (CBR) test - IS : 2720 (Part16) -1987

Compaction Test

This Phase of Study involved a detailed investigation of the compaction characteristics of the parent soil and blendedsample containing different percentages of waste plastic and fly ash contents, in order to obtain the optimum moisture contents and maximum dry densities. The optimum moisture contents

thus obtained are used in preparing samples for CBR test & Unconfined Compressive Strength Test. This test confirms to IS: 2720 (Part 8) 1983.

Sample Preparation

For parent soil 2.5 kg of oven dried soil sample is taken on trayand thoroughly mixed with water. For the blended mixtures the quantity of soil depends upon the ratio at which it is desired to be mixed with other additives. The amount of water mixed at first trial may vary according to the soil sample composition.

Procedure

The mixed sample is placed in previously weighted (m_i gm) mould of capacity 2250 cc. in five layers. Each layer is given 25 blows with a 4.9 kg rammer with free fall height of 450 mm. After five successive layers collar is removed and excess soil is trimmed off. The weight of mould with soil is taken (m_2 gm). This process is repeated for other water content also until there is a decrease in m_2 value. For each trial a portion of soil is taken for moisture content determination.

Calculation

Bulk density of soil, $\gamma = (m_2\text{-}m_l)/2250$ Dry density of soil, $\gamma_a = \gamma/(1+w)$, Where w = moisture content present in soil.

Unconfined Compressive Strength Test

This test confirms to IS 2720 (Part 10): 1991SAMPLE PREPARATION

Cylindrical specimen is compacted by static compaction in 3.8 cm diameter and 7.6 cm high mould. The inner surface ofthe mould is lubricated with mobile oil to extrude the sample from mould with minimum disturbance. The sample is placed inside the specimen mould in seven layers using spoon, leveled and gently compacted. Pressure pad will be inserted into the mould and the whole assembly will be statically compacted in loading frame to the desired density. The sample is to be kept under static load for not less than 10 minutes in order to account for any subsequent increase in height of sample due to swelling. The sample will then be removed from the mould with the help of sample extruder. Initial dimensions are measured. Axial strain, $e = (\Delta L / Lo)$

Where, ΔL = change in length after failure L = initial lengthof the specimen Average cross-sectional area after failure,

Where, A_o = Initial Average cross-sectional area ofSpecimen. Compressive Stress, $\sigma_o = (P/A)$

California Bearing Ratio (CBR) Test

The CBR is a measure of resistance of a material to penetration of standard plunger under controlled density and moisture conditions. The CBR test may be conducted in re-moulded or undisturbed specimen in the laboratory. The test is simple and has been extensively investigated for field correlations of flexible pavement thickness requirement. The test is conducted by causing a cylindrical plunger of some diameter to penetrate a pavement component material at 1.25mm/minute. The loads, for 2.5mm and 5mm arerecorded. This load is expressed as a percentage of standard load value at a respective deformation level to obtain C.B.R. value. The values are given in the table 3.

Table 3 Standard Load Value at a Respective Deformation toobtain C.B.R. Value

Soil sample	CBR Stress
Normal soil	12.47
0.5% plastic strip and 5% fly ash	21.84
1% plastic strip and 5% fly ash	13.04

For Soil stabilized with waste plastic and 15% fly ash, fly ash, the CBR value has been observed decreasing trend for waste plastic with respect to parent soil.

For Soil stabilized with waste plastic and 20% fly ash, the CBR value has been observed increasing trend up to 1.0% waste plastic and after that the CBR value start to decreasing with respect to parent soil.

With increase in percentage of waste plastic there is increasing trend in CBR upto the 0.5% of waste plastic after that decreasing trend in CBR is observed. The increase in fly ash percentage the CBR has increasingtrend up to 10% and further addition of fly ash the CBR shows decreasing trend.

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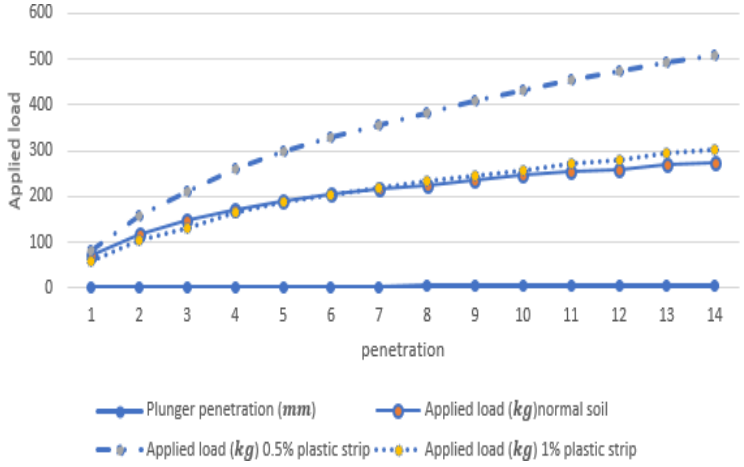

Fig 1 CBR test result of soil

Unconfined Compressive Strength (UCS) test

Table 4 UCS test results

Soil Sample	Stress
Normal Soil	129.735
0.5 % plastic strip and 5 % fly ash	331.880
1 % plastic strip and 5 % fly ash	196.112

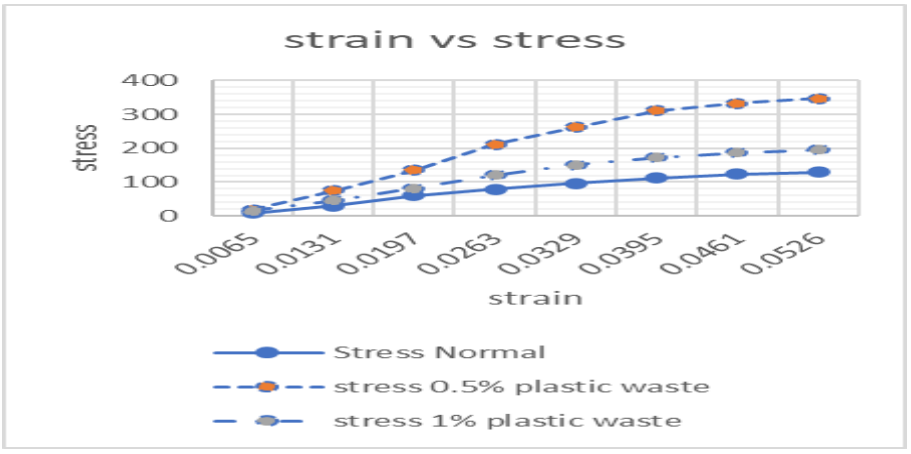

Fig.2 Unconfined Compressive Strength test results

V. CONCLUSION

The study demonstrates the influence of waste plastic on theCBR and stress strain characteristics of compressible. The following conclusions have been drawn based on the laboratory investigations carried out in this study:
Based on the results obtained and comparisons made in the present study, the following conclusions can be drawn:

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- The Maximum Dry Density (MDD) value of the black cotton soil initially decreased with the addition of plastic strip and fly ash
- The Unconfined Compressive Strength (UCS) of the soil with variation of plastic strip and fly ash content showed similar trend as that of the MDD values, except the fact that the peak value was observed for a plastic strip and fly ash content of 0.5% by weight.
- In un-soaked California Bearing Ratio (CBR) tests of soil conducted with varying plastic strip and fly ash content, the CBR increased gradually with the increase in plastic strip and fly ash content till its valuation was 0.5% by weight of the total mixture; it decreased thereafter.
- The change in case of soaked California Bearing Ratio (CBR) tests of soil with varying plastic strip and fly ash content was, however, uneven. It decreased with the initial addition of plastic strip and fly ash (1% by weight of total mixture).
- With the increasing plastic strip and fly ash content in the soil-plastic-ash mixture, the decrease in value of free swell ratio was remarked. This decrease was also reciprocated by the plasticity index values. Plasticity index values are directly proportional to percent swell in an black cotton soil, thus affecting the swelling behavior of the soil-plastic-fly ash mixture.
- Thus, plastic and fly ash as an additive decreases the swelling and increases the strength of the black cotton soil.

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