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EFFECT OF PLASTIC WASTE ON STRENGTH OF CLAYEY SOIL MIXED WITH FLY ASH

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Abstract: This paper present the effect of plastic waste as a strips on the strength of clayey soil and clay-fly ash mixture and the results are presented in term of compressive strength, shear strength, california bearing ratio CBR) characteristics. The different percentage of plastic waste 0.5%, 1.0%, 1.5% and 2.0% by dry weight of 10mm length and 5 mm width) and 5%, 10%, 15% and 20% fly ash by weight were mixed into the clayey soil. With increase in percentage of waste plastic there is increasing trend in MDD upto the 1.5% of waste plastic after that decreasing trend in MDD is observed. Though, a increase in OMC has been observed with increase in percentage of waste plastic. The increase in fly ash percentage the MDD having increasing trend up to 10% and further addition of fly ash the MDD shows decreasing trend . Though, a increase in OMC has been observed with increase in percentage of fly ash. With increase in percentage of waste plastic there is increasing trend in UCS upto the 1.5% of waste plastic after that decreasing trend in UCS is observed. The increase in fly ash percentage the UCS having increasing trend up to 10% and further addition of fly ash the UCS shows decreasing trend . 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 having increasing trend up to 10% and further addition of fly ash the CBR shows decreasing trend .The present study will help in consuming the considerable quantity of waste plastic thereby reducing the environmental threat.

I. INTRODUCTION

Soil Stabilization is the process of blending and mixing materials with a 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 create significant problems for pavements. Lack of adequate road network 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 enable reduction in construction cost and improved performance for roads. Fly ash is the residue produced from the 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 of cement and bricks, landfiiling, 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 the need 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 mineral. 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 specially 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 reinforcement of soil by using fibres 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 invention in many aspects of life. The amount of plastic waste is increasing year by year. Due to this the need of 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. Hence to make the development path sustainable the use of plastic waste in geotechnical engineering needs to be encouraged. By doing so, Properties of soil will be improved and reuse of plastic can also be made efficiently.

Plastics waste is of two types:

- Pre-use plastic (production scrap)
- Post-use plastic Pre-use plastic

That plastic which does not fulfil the desired requirement during casting and assembly i.e. material that has the mismatching colour, undesirable hardness, or wrong processing characteristics are called Pre-use plastic waste. This material is easy to use for other applications and has the property to get recycled. Pre-use plastic waste is the ultimate source of plastics which are suitable for reprocessing from manufacturers of plastic products. Processing of Pre-used plastic is less as compared to post-use hence Pre-use is more valuable then Post-use plastic.

II. OBJECTIVE OF THE STUDY

To check and improving the CBR and shear strength value by adding plastic waste and fly ash. Moreover pavement on clayey soil requires a greater thickness of base and sub-base course which results increases the expenditure of project. To set right this problem it becomes mandatory to increase the strength of the soil which in-turn will help in lessening the thickness of the pavement layers and thus project cost.The common additives which are widely used in stabilizing the soil are cement and lime. Lime is preferred over cement stabilization because lime is cheaper than cement and Carbon-Di-Oxide (C02), which causing detrimental to the environment, is emitted during the production of cement. Lime stabilization is requires adequate clay content and a relatively high curing temperature and hence it is more suitable for tropical and sub-tropical countries like India. Cement is generally used where clay content in soil is comparatively less and the temperature is relatively less. Researchers are going on for alternative by-products to cement ,fly ash and lime which not only satisfy the engineering requirements and cause no pollution but also be cost effective. Present thesis makes the use of plastic waste and fly ash with the soil and finds the changes in the soil properties.

III. 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 analysed 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 in order 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 method. the cost of adding these additives has tremendously increased in past few years; there for 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 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 percentage of plastic (0.5%, 1%, 1.5%, 2 % & 2.5%) to calculate CBR. on the basis of experiments that he concluded using plastic waste strips will improve the soil strength and can be used as sub grade . It is economical and eco-friendly method to dispose 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 on 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 so as 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 geotechnical properties of locally available clayey soil can be visualized from this study.

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 fiber 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.

IV. MATERIAL USED

SOIL :- Nearly 100 Kg of locally available clayey soil was collected from Mathana. 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

S. No.	Parameters	Result
1.	Modified Compaction Test MDD (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 purchased from the market of Ambala. The Plastic are cut into pieces of approximately 10mm lengths & 5mm width and are mixed in percentage of 0.5%, 1.0%, 1.50% and 2.0% by dry weight of soil.

FLY ASH

The fly ash was collected from the Thermal Power Plant, Panipat. The fly ash was oven dried and was passed through 300 micron sieve. The fly ash was mixed with parent soil in percentage of 5%, 10%,15% and 20%. The chemical properties of Fly ash is given in Table 2.

Table 2 chemical properties

Sr. No.	Parameter	%age
1	SiO_2	56.33
2	Al_2O_3	23.45
3	Fe_2O_3	5.19
4	TiO_2	0.94
5	CaO	3.47
6	MgO	0.63
7	SO_3	0.44
8	K_2O	1.30

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
- Unconfined Compression Test - IS : 2720 (Part 10) – 1991
- California bearing ratio (CBR) test - IS : 2720 (Part 16) – 1987

V. METHODOLOGY

Compaction Test

This Phase of Study involved a detailed investigation of the compaction characteristics of the parent soil and blended sample containing different percentage 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 is 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 5 kg of oven dried soil sample is taken on tray and 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): 1991

SAMPLE PREPARATION

Cylindrical specimen is compacted by static compaction in 3.8 cm diameter and 7.6 cm high mould. The inner surface of the mould is lubricated with mobile oil so as 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.

PROCEDURE

The sample is placed on the pedestal of the Strain controlled tri-axial cell with non- pervious discs at the top and bottom. A loading platen will be placed at the top which is connected through loading piston to the proving ring. The sample arrangements are brought in the contact of deformation dial gauge. The axial strain rate is chosen as 1.0 mm/minute by appropriate setting of turret lever and strain setting lever. The compressive stress taken by the sample will be recorded at various strain levels until the sample fails. The dimensions are noted down.

For measurement of compressive stress taken by the sample, 250 kg capacity proving ring with proving ring constant of 0.25 kg/division. Proving ring and deformation dial gauge installed in the testing programme is having least count of 0.002 mm and 0.01 mm respectively.

CALCULATION

Axial strain, $e = (\Delta L / Lo)$

Where, ΔL = change in length after failure L = initial length of the specimen

Average cross-sectional area after failure,

Where, A_o = Initial Average cross-sectional area of Specimen. 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 are recorded. 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

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

Penetration, mm	Standard Load, kg	Unit Standard Load, Kg/Cm^2
2.5	1370	70
5.0	2055	105
7.5	2630	134
10.0	3180	162
12.5	3600	183

PROCEDURE

Place the mould assembly with the surcharge weights on the penetration test machine. Seat the penetration piston at the center of the specimen with the smallest possible load, but in no case in excess of 4 kg so that full contact of the piston on the sample is established. Set the stress and strain dial gauge to read zero. Apply the load on the piston so that the penetration rate is about 1.25 mm/min.

Record the load readings at penetrations of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 7.5, 10 and 12.5 mm. Note the maximum load and corresponding penetration if it occurs for a penetration less than 12.5 mm. Detach the mould from the loading equipment. Take about 20 to 50 g of soil from the top 3 cm layer and determine the moisture content.

The C.B.R. values are usually calculated for penetration of 2.5 mm and 5 mm. Generally the C.B.R. value at 2.5 mm will be greater that at 5 mm and in such a case/the former shall be taken as C.B.R. for design purpose. If C.B.R. for 5 mm exceeds that for 2.5 mm, the test should be repeated. If identical results follow, the C.B.R. corresponding to 5 mm penetration should be taken for design.

VI. RESULTS AND DISCUSSIONS

Moisture-density relationship

Modified Proctor tests have been conducted to determine optimum moisture content (OMC) and maximum dry density (MDD) of soil stabilized with various percentages of waste plastic and fly ash as reported in Table A.1. Fig B.1 to B.4 shows comparison of OMC and MDD respectively for parent soil stabilized with different percentages of waste plastic and fly ash.

For parent clay OMC and MDD have been observed as 17.69% and 1.73 g/cc respectively.

For soil stabilized with waste plastic and 5% fly ash, OMC varies from 15.28 to 18.05% and MDD varies from 1.77 to 1.70 g/cc , with increase in percentage of waste plastic from 0.5% to 2.0%.

For soil stabilized with waste plasric and 10% fly ash, OMC varies from 15.76 to 18.39% and MDD varies from 1.78 to 1.75 g/cc , with increase in percentage of waste plastic from 0.5% to 2.0%.

For soil stabilized with waste plastic and 15% fly ash, OMC varies from 16.58 to 18.32% and MDD varies from 1.74 to 1.69 g/cc , with increase in percentage of waste plastic from 0.5 % to 2.0%.

For soil stabilized with waste plastic and 20% fly ash, OMC varies from 17.05 to 18.65% and MDD varies from 1.72 to 1.68 g/cc , with increase in percentage of waste plastic from 0.5 % to 2.0%.

With increase in percentage of waste plastic there is increasing trend in MDD upto the 1.5% of waste plastic after that decreasing trend in MDD is observed. Though, a increase in OMC has been observed with increase in percentage of waste plastic.

The increase in fly ash percentage the MDD having increasing trend up to 10% and further addition of fly ash the MDD shows decreasing trend . Though, a increase in OMC has been observed with increase in percentage of fly ash.

Stress- Strain Relationship

Unconfined Compressive Strength tests have been conducted to determine UCS of soil stabilized with various percentages of waste plastic and fly ash as reported in Table A.2 to A.18 and B.9 to B.31 show comparison of stress and strain respectively. For parent clay UCS have been observed as 1.06 kg/cm^2 .

For Soil stabilized with waste plastic and 5% fly ash, the UCS value has been increasing trend upto 1.5% waste plastic and after that the UCS value start to decreasing with respect to parent soil.

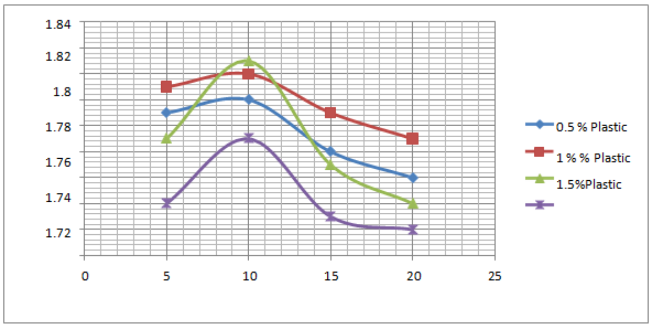
For Soil stabilized with waste plastic and 10% fly ash, the UCS value has been observed increasing trend up to 1.5% waste plastic and after that the UCS value start to decreasing with respect to parent soil.

For Soil stabilized with waste plastic and 15% fly ash, the UCS value has been observed increasing trend up to 1.5% waste plastic and after that the UCS value start to decreasing with respect to parent soil.

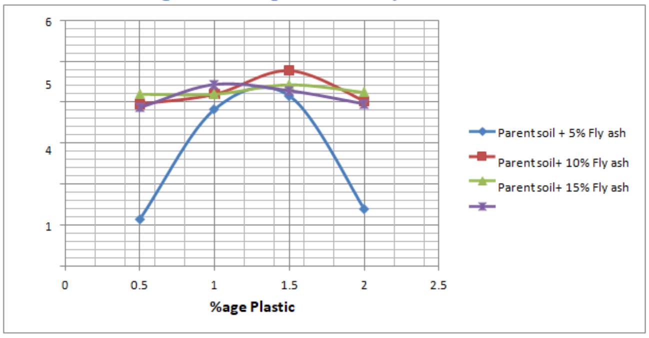
For Soil stabilized with waste plastic and 20% fly ash, the UCS value has been observed increasing trend up to 1.0% waste plastic and after that the UCS value start to decreasing with respect to parent soil.

With increase in percentage of waste plastic there is increasing trend in UCS upto the 1.5% of waste plastic after that decreasing trend in UCS is observed.

The increase in fly ash percentage the UCS having increasing trend up to 10% and further addition of fly ash the UCS shows decreasing trend .



Graph 1 Showing Maximum Dry Density Relationship with Different Percentage of Waste plastic and Fly ash with Parent Soil



Graph 2 Showing Unconfined Compressive Strength Relationship with Different Percentage of Waste Plastic

CBR Result

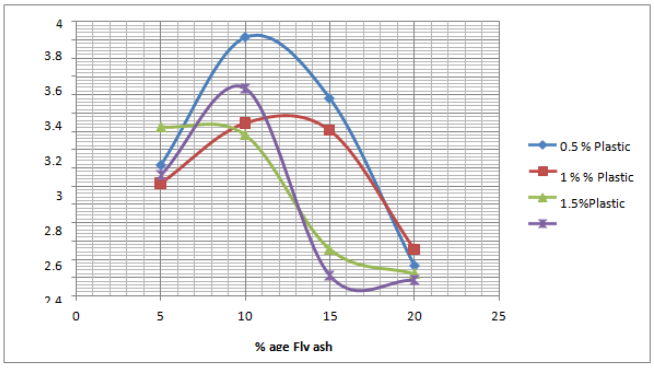
The CBR tests were conducted as per IS 2720(Part 16) - 1987. CBR is the prime factor which determines the thickness of each pavement layer in the design of pavement .It is the ratio expressed in percentage of force per unit area required to penetrate a soil mass. The load values to cause 2.5mm and 5mm penetration are noted. These loads are expressed as standard load values. The standard load values are 1370kg and 2055 kg at 2.5mm and 5.00mm respectively. Generally, the CBR value at2.5mm penetration will be greater than that at 5mm penetration. The soaked CBR value is determined by subjecting the specimen in the mould for four day soaking. California Bearing Ratio test was performed on the soil sample mixed with varying amount of waste plastic and fly ash at MDD and OMC determined from compaction test. From this test the strength characteristics of the soil samples are studied by determining California Bearing Ratio value. The CBR result of various samples mixed with different percentage of waste plastic with fly ash are noted.

For parent clay CBR have been observed as 0.89 % .

For Soil stabilized with waste plastic and 5% fly ash, the CBR value has been increasing trend upto 1.5% waste plastic and after that the CBR value start to decreasing with respect to parent soil.

For Soil stabilized with waste plastic and 10% 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 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 having increasing trend up to 10% and further addition of fly ash the CBR shows decreasing trend .



Graph 3 Showing CBR with Different Percentage of Fly Ash

VII. CONCLUSION

The study demonstrates the influence of waste plastic on the CBR and stress strain characteristics of compressible locally available clay. The following conclusions have been drawn based on the laboratory investigations carried out in this study:

- With increase in percentage of waste plastic there is increasing trend in MDD upto the 1.5% of waste plastic after that decreasing trend in MDD is observed. Though, a increase in OMC has been observed with increase in percentage of waste plastic.
- The increase in fly ash percentage the MDD having increasing trend up to 10% and further addition of fly ash the MDD shows decreasing trend . Though, a increase in OMC has been observed with increase in percentage of fly ash.
- It has been observed that there is increasing trend up to 1.50 % waste plastic after that having decreasing trend in the UCS value with the addition of waste plastic and Fly ash to the parent soil.
- The increase in fly ash percentage the UCS having increasing trend up to 10% and further addition of fly ash the UCS shows decreasing trend .
- It has been observed that there is increasing trend up to 0.50 % waste plastic after that having decreasing trend in the CBR value with the addition of waste plastic and Fly ash to the parent soil. These values of CBR for soil treated with various percentages of waste plastic and fly ash will help in proper designing of the Pavement on the basis of strength criteria.
- It has been observed that there is increasing trend up to 10 % Fly ash after that having decreasing trend in the CBR value with the addition of Fly ash and Plastic to the parent soil. These values of CBR for soil treated with various percentages of waste plastic and fly ash will help in proper designing of the Pavement on the basis of strength criteria.

Scope of further research
A number general research suggestions are listed herein that should increase this knowledge and enable the waste plastic and fly ash to become more useful engineering materials.

- For advance research, it is recommended that the effect of combining the waste plastic with additives such as lime or cement can be investigated that can further improve the properties of stabilized soil.
- Comparative study on soil treated with waste plastic and man-made fibres may be done.
- Further research may be done in this direction to know the exact cause and remedial measures against the failure of structures resting on expansive soils.
- Experimental studies can be done on soil stabilized waste plastic to determine other properties such as strength, permeability etc.

REFERENCES

[1] IS: 1498 (1970), "Indian Standard Methods of Test for Soils: Classification and Identification of Soil for General Engineering Purposes", Bureau of Indian Standards.
[2] IS : 2720 (Part 8) - 1983 "Indian Standard Methods of Test for Soils: Determination of Moisture Content-Dry Density Relation using Heavy Compaction", Bureau of Indian Standards.
[3] Singh, Alam and Chowdhary, G.R. (1994), "Soil Engineering in Theory and Practice", Geotechnical Testing and Instrumentation, Vol. 2, CBS Publishers and Distributors, Delhi.
[4] Ranjan, Gopal and Rao, A.S.R. (2000), "Basic and Applied Soil Mechanics", New Age International (P) Ltd., New Delhi.
[5] Ru, Zhang Ji and Xing, Cao, (2002), "Stabilization of Expansive soil by Lime and Flyash", Journal of Wuhan University of Technology, Vol.17, No.4.
[6] Cai, Yi,Shi, Bin, Ng, Charles W.W., Tang, Chao-sheng (2006), "Effect of polypropylene fibre and lime admixture on engineering properties of clayey soil", Engineering Geology, 87, pp 230–240.
[7] Tang, Chaosheng, Shi, Bin, Gao, Wei, Chen, Fengjun, Cai, Yi (2007), "Strength and mechanical behavior of short polypropylene fiber reinforced and cement stabilized clayey soil", Geotextiles and Geomembranes, 25, pp 194–202.
[8] Naeini, S.A. and Sadjadi, S. M. (2009), " Effect of waste polymer materials on shear strength of unsaturated clays", 2ndInternational Conference on New Developments in Soil Mechanics and Geotechnical Engineering, Near East University, Nicosia, North Cyprus, pp. 350-358.

[9] Maheshwari, Kalpana Vinesh, Desai, Atul K. and Solanki, Chandresh H. (2011), "Performance of Fiber Reinforced Clayey Soil", EJGE, Vol. 16, pp. 1067-1082.
[10] Estabragh, A. R.,Bordbar, A. T. andJavadi, A. A. (2011) "Mechanical Behavior of a Clay Soil Reinforced with Nylon Fibers", Geotech Geol Eng, 29, pp. 899–908.
[11] Pradhan, Pradip Kumar, Kar, Rabindra Kumar and Naik, Ashutosh (2012), "Effect of Random Inclusion of Polypropylene Fibers on Strength Characteristics of Cohesive Soil", Geotech Geol Eng, 30, pp. 15–25.
[12] Sharma, R. K. (2012), "Subgrade Characteristics of Locally Available Soil Mixed With Fly Ash and Randomly Distributed Fibers", International Conference on Chemical, Ecology and Environmental Sciences (ICEES'2012), Bangkok, pp. 177-181.
[13] Sayyed Mahdi Hejazi, Mohammad Sheikhzadeh, Sayyed Mahdi Abtahi, Ali Zadhoush (2012), "A simple review of soil reinforcement by using natural and synthetic fibers", Construction and Building Materials, 30, pp. 100-116.
[14] Akshat Mehrotra, Hadi Ghasemian, D.R. Kulkarni, and N.R. Patil(2014):"effect of HDPE plastic on the unconfined compressive strength of black cotton soil" IJIRSET January 2014/vol. 3/issue 1
[15] Babita Singh, Amrendra Kumar, Ravi Kumar Sharma (2014):"effect of waste materials on strength characteristics of local clay " International Journal of Civil Engineering Research 2014 vol. 5.
[16] Dr. A.I. Dhatrak, S.D. Konmare (2015): "performance of randomly oriented plastic waste in flexible pavement" IJPRET march 2015/vol. 3/no. 9/193-202.
[17] Vijay Kumar Patidar, Dr. Suneet Kaur (2016) "A Review Literature on the Use of Waste Plastic to Improve Geotechnical Properties of Soil", International Research Journal of Engineering and Technology (IRJET), Volume: 03 Issue: 06.
[18] Palak Chopra , G.S Bath , Amanpreet Singh Virk (2017)," Influence of Waste Fly Ash on Characteristics of Clayey Soil", International Journal of Engineering Science and Computing.
[19] Sharan Veer Singh, Mahabir Dixit (2017)," Influence Stabilization of Soil by Using Waste Plastic Material", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 6, Issue 2, February 2017.
[20] Saket Dixit (2017)," Effect of Waste Plastic on the Strength Characteristics of the Subgrade for the Flexible Pavement", Global Research and Development Journal for Engineering, Vol. 2, Issue 11, October 2017.
[21] Tinku Kalita,Anita Saikia,Bhaskarjyoti Das (2017)," Effect of Fly ash on the Strength Behaviour of the Clayey Soil", International Research Journal of Engineering and Technology (IRJET), Volume: 04 Issue: 07. July 2017
[22] R.R Pandya, A.J Shah (2017)," Effect Alkali activated Fly ash on the Strength of Clayey Soil", Indian Geotechnical Conference , December 2017

