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STRENGTH IMPROVEMENT OF CLAYEY SOIL WITH WASTE PLASTIC STRIPS AND CEMENT KILN DUST

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Abstract- **Due to clayey soil's behaviour such as its low bearing capacity, high shrinkage and swell characteristics, there is necessity to stabilize such soil. During this study effort has been made to enhance the strength properties of clayey soil. The high exploitation of natural soil materials and traditional stabilizing materials for them, there is a great need to identify and use the waste materials in the best possible way in order to lessen the burden on the natural soils. Secondly, use of waste materials can also resolve the problem of their disposal, hence helping in avoiding the pollution due to this disposal process. Among many waste materials, plastic may also be used beneath the theme of reduce, recycle and reuse and it has been already established by several researchers that such waste can be effectively utilized as a stabilizing agent for soils.**
Cement Kiln Dust on the other hand is a particulate matter that is collected from cement kiln exhaust gases and consists of particles of clinker, unreactive and partially calcined raw materials, and fuel ash enriched with alkali sulphates, halides and other volatiles. The most common and economical method for stabilizing expansive soils is using admixtures that prevent volume changes. Cement Kiln Dust is one such material. This project includes the addition of suitable admixtures such as plastic wastes. The waste plastic material i.e. plastic bottle strips are used. The waste plastic bottles are taken and cut into small strips. The addition of these small strips in the expansive soil are done by different percentages along with cement kiln dust and tests such as liquid limit, plastic limit, compaction test, are performed. In the recent construction experience in the area of study the few last years showed that ground and underground engineering on the soft soil are susceptible to various types of cracking in buildings and road pavements. Hence, the aim of this paper is to explore the potentials of CKD and plastic strips for improving properties of soil. In the present study the cement kiln dust is used in different percentages such as 10%, 15%, 20% and 25%. The Plastic Strips percentage is varied as 0.5%, 1% and 1.5% and its size is taken as (10*20) mm.

Keywords— **Expansive Soil, Soil Stabilization, cement kiln dust (CKD), lime, cement, Plastic strips.**

I. INTRODUCTION

A soil is defined as unconsolidated mineral or organic matter on the surface of earth that has been subjected to and show effects of genetic and environmental factors. It is formed by the decomposition of rocks under the influence of naturally occurring conditions such as wind, rain, heat, etc. There is a need to select good soil conditions for proper safety consideration of all the construction projects. In India near about 20 % of land cover mostly consists of expansive soils, the fact which can't be ignored. Such soils exhibit extreme stages of consistency from very hard to very soft when saturated. Clayey soils contain minerals that are capable of absorbing water. They undergo severe volume changes corresponding to changes in moisture content. Due to these reasons clayey soils are generally poor material for construction. So to improve the engineering properties of soil, stabilization or reinforcement is done. Soil stabilization is the process of blending and mixing materials to improve engineering properties of soil like increasing shear strength, compressibility and permeability, thus improving load bearing capacity of a sub-grade to support pavements and foundations. Stabilization of soils is an effective method for improving the properties of soil and pavement system performance. The objectives of any stabilization technique used are to increase the strength and stiffness of soil, improve workability and constructability of the soil and reduce the Plasticity Index. For any given soil many stabilization methods, using different stabilizing agents, may be effective to improve the soil properties in-place rather than removing and replacing the material. Availability or financial considerations may also be the determining factor on which a stabilizing agent is selected. The classification of different soils are presented in order to classify, the good and poor soil, otherwise called as problematic soil. Keeping these objectives in mind this project is taken for the utilization of Cement kiln Dust and Plastic waste strips as stabilizing agents to enhance the engineering properties of soil.

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II. EXPERIMENTAL WORK

MATERIALS:

Soil: Soil used in this study work was obtained from Indira Nagar, Jammu, J&K (India) from about 1.5m below natural ground. The soil was hand sorted to remove any pebbles and vegetative matter. The soil was oven dried before using it for experimental work. Physical properties of soil determined from this study are in the table below:

Table 1: Properties of Soil Sample

Sr. No.	Parameters	Values
1	Color	Brown
2	Liquid Limit (%)	53
3	Plastic Limit (%)	28
4	Plasticity Index (%)	25
5	Specific Gravity	2.56
6	Optimum Moisture Content	10.31
7	Maximum Dry Density	1.89

Plastic Strips: Plastic and materials made with plastic have become the necessary part of our daily life in various stages and also in various forms, but then, the disposal of the used and unwanted plastic has become a major threat for the civilized world. Plastic strips used in the study were extracted from locally available plastic mineral water bottles. These are made from Polyethylene terephthalate (PET). It is chemically unreactive i.e. it doesn't react with water or food. It is very lightweight and naturally transparent. Its density is 0.049 and specific gravity is 1.38. The size of a strips is taken as (10*20) mm. The tests were conducted at various strip contents of 0.5%, 1%, and 1.5% of the dry weight of soil.

Cement Kiln Dust: Cement kiln dust (CKD) is the one of the industrial waste products, which is a by-product of Portland cement manufacturing process. CKD consists primarily of calcium oxide and silicon dioxide which is similar to the cement kiln raw feed, but the amount of alkalis, chloride and sulphate is usually considerably higher in the dust. Many factors influence the chemical and physical properties of Cement Kiln Dust, because operations of plant differ with respect to raw feed, type of operation, dust collection facility, and type of fuel used. The research described in this study was conducted exclusively with pre-calciner Cement Kiln Dust from Khanday Cement Kiln Plant near kathua district, Jammu (INDIA).

Table 2: Typical Chemical Composition of Cement Kiln Dust

Oxide	CaO	Al2O3	SiO2	Fe2O3	Mn2O3	Na2O	K2O
Conc. %	50.81	4.71	17.18	1.92	0.002	0.001	1.35

METHODS

To study about the soil stabilization, soil is mixed with CKD and Plastic strips, their engineering properties are determined. To achieve the desired objective of the thesis, the following tests were performed as per Indian standard codal provision:

1. Unconfined compressive strength
2. California Bearing Ratio (CBR)

III. RESULT AND DISCUSSION

Unconfined Compressive Strength

The optimum mix having highest UCS values for the different curing periods i.e 3, 7, 28 days. The compressive strength of treated soil is much greater than untreated soil. For different curing periods, the strength of the stabilized soil increases with increase in curing periods. The UCS value of the stabilized mix increases from 85 kPa to 746 kPa at 28 days curing for 15% of Cement Kiln Dust and 1 % with 84 % of soil. For 84: 15: 01 (Soil: CKD: PS) mix, the UCS value increases from 85 to 411 kPa, 544 kPa and 746 kPa for 3, 7 and 28 days of curing periods, respectively. The increase in compressive strength is due to pozzolanic action, the fibre content in Plastic strips causes frictional resistance and cohesion in the clay.

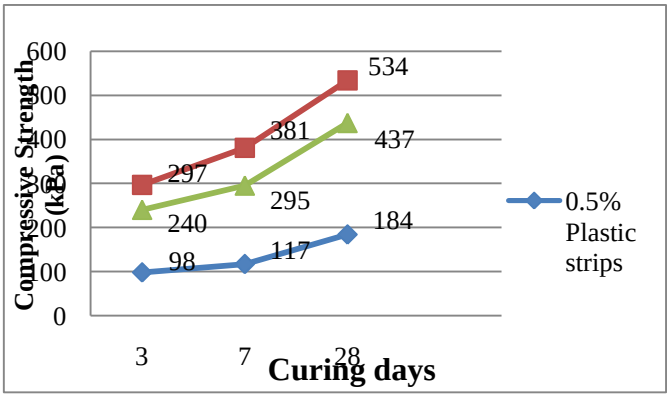

Fig 1. Compressive strength v/s curing days of 10 % CKD with 0.5%, 1%, 1.5% of Plastic strips with various proportions of Soil.

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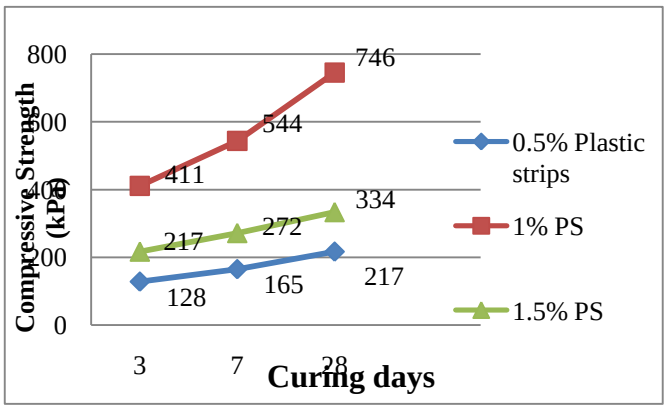

Fig 2. Compressive strength v/s curing days of 15 % CKD with 0.5%, 1%, 1.5% of Plastic strips with various proportions of Soil.

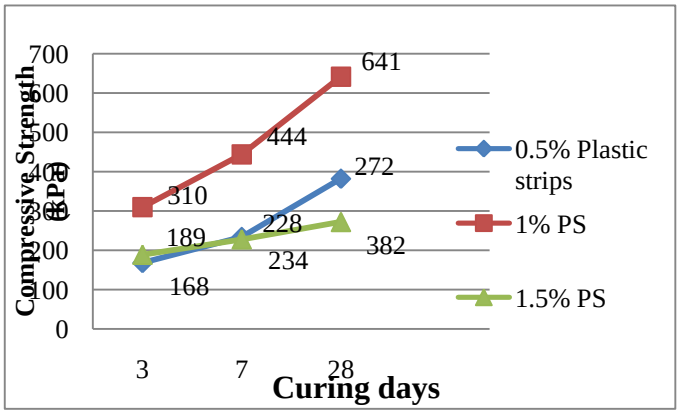

Fig 3. Compressive strength v/s curing days of 20 % CKD with 0.5%, 1%, 1.5% of Plastic strips with various proportions of Soil.

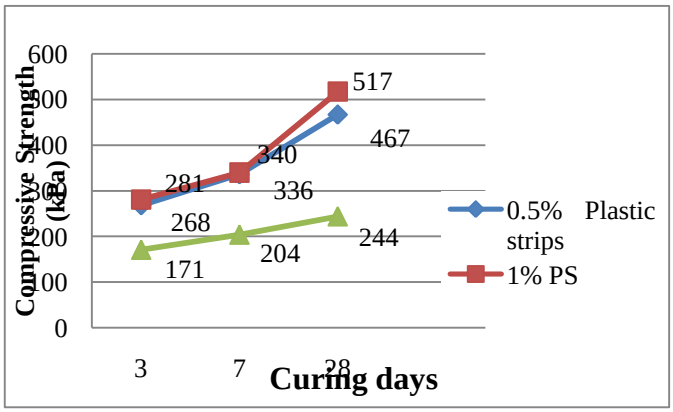

Fig 4 Compressive strength v/s curing days of 25 % CKD with 0.5%, 1%, 1.5% of Plastic strips with various proportions of Soil.

Table 3. UCS Values Of Various Mix Proportion At Different Curing Periods

Soil : CKD : Plastic Strips (%)	UCS (kPa) 3days curing	UCS (kPa) 7days curing	UCS (kPa) 28days curing
100:0:0	85	85	85
89.5:10:0.5	98	117	184
84.5:15:0.5	128	165	264
79.5:20:0.5	168	234	382
74.5:25:05	268	336	467
89:10:1	297	381	534
84:15:1	**411**	**544**	**746**
79:20:1	310	444	641
74:25:1	281	340	517
88.5:10:1.5	240	295	437
83.5:15:1.5	217	272	334
78.5:20:1.5	189	228	272
73.5:25:1.5	171	204	244

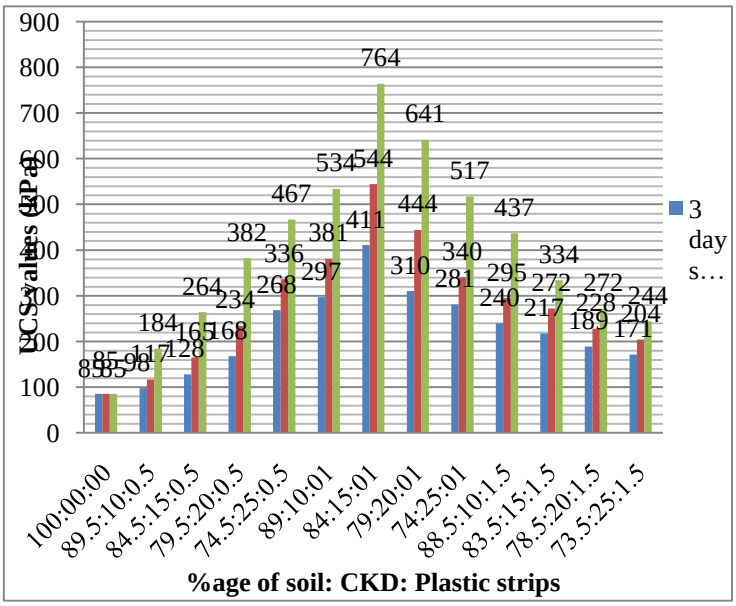

Fig 5. UCS values with various proportions of soil, Cement kiln dust and plastic strips

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4.5 California Bearing Ratio

California Bearing ratio test is the penetration test to check the strength of subgrade of the pavement. In this test the unsoaked sample of 100 % soil is taken i.e. pure soil and of optimum mix i.e. 84:15:01 (Soil: CKD: Plastic strips). Two values above and below of the optimum mix are also taken. The test shows that there is increase in the CBR value from 2.91% to 7.21%.

Table 4 : Summary of test results of soaked CBR performed for different percentages of CKD and Plastic strips

Soil: CKD: Plastic Strips	CBR (%)
100: 0: 0	2.91
89: 10: 1	5.28
84: 15: 1	7.21
79: 20: 1	6.73

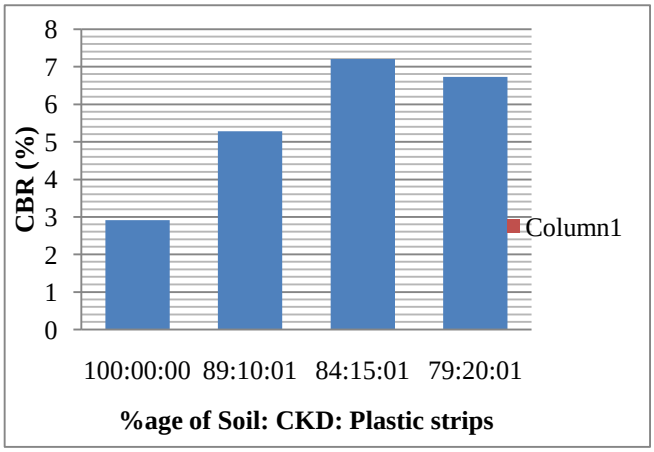

Fig 6. CBR (%) values with various proportions of soil: CKD: Plastic strips

From the figure, it has been observed that the value California Bearing Ratio (CBR) increased with increase of percentage of plastic strips content up to optimum mix, after that it is decreased a little and it is maximum at 84:15:01 (soil: CKD: Plastic strips) of the dry weight of soil. In this test we have calculated CBR (%) for virgin soil sample and the optimum mix along with more samples which are above and below the optimum mix.

IV. CONCLUSION

Based on the obtained results and discussion thereof following conclusions can be made:

1. The optimum mix is found to be 84% soil, 15% CKD and 1% Plastic strips on the basis of compaction test.

2. Liquid limit decreases and Plastic limit of soil increases as the percentage of CKD increases. The Plasticity index of soil reduces with increased CKD content. Reduction in Plasticity index is quite visible. Hence, the soil samples become less plastic and compressible.

3. The MDD decreases from 1.89 to 1.65 and OMC increases from 10.31 to 22.13 with increase in percentage of CKD and Plastic strips into the soil.

4. The unconfined compressive strength of stabilized samples increases with increase in percentage of CKD and Plastic strips up to the optimum value and after that it decreases.
The unconfined compressive strength of stabilized samples increases with increase in 3, 7 and 28 days of curing up to the optimum mix.

5. Unsoaked CBR value of soil increases with increasing the percentages of CKD and Plastic strips. Although in this test we have calculated CBR(%) for virgin soil sample and the optimum mix along with two more samples which are above and below the optimum mix. They show an increase in the CBR (%) upto optimum mix and after that there is a slight decrease.
6. Using Plastic bottles as a soil stabilizer is an economical and gainful utilization since there is scarcity of good quality soil for embankments and fills.

7. This new technique of soil stabilization can be effectively used to meet the challenges of society and it can significantly enhance the properties of soil used in construction of road infrastructure, foundation, stabilization of embankment, pavement sub grade and other different fields as per the needs and flexibility. Further large-scale research is advisable to determine the boundary effects influence on test and for its more effectiveness.

8. This project is to meet the challenge of society to reduce the quantities of plastic wastes.

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