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Strength Improvement of Clayey Soil with Waste Plastic Strips and Cement Kiln Dust

Shafat Hassan[1], Neeraj Sharma[2]

[1]*Post Graduate Student, Department of Civil Engineering, SSCET, Pathankot, Punjab, India*
[2]*Assistant Professor, Department of Civil Engineering, SSCET, Pathankot, Punjab, India*

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.*

Key Words: *Expansive Soil, Soil Stabilization, cement kiln dust (CKD), lime, cement, Plastic strips.*

1. 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.

1.1 MATERIALS:

1.1.1 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 type in study is clayey soil which is a kind of an expansive soil. They exhibit high rate of swelling and shrinkage when exposed to changes in moisture content because of the

presence of montmorillonite which leads to formation of cracks in soil. Hence, the need for stabilisation. The soil was oven dried before using it for experimental work.

1.1.2 Plastic Waste 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.

1.1.3 Cement Kiln Dust (CKD)

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 J&K (INDIA).

Table 1: Typical Chemical Composition of Cement Kiln Dust

Oxide	CaO	Al2O3	SiO2	Fe2O3	Mn2O3	Na2O	K2O	Loss of ignition
Concentration %	50.81	4.71	17.18	1.92	0.002	0.001	1.35	24.03

1.2 Methodology

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:

- Consistency limit test (IS: 2720, Part-V)
- Compaction characteristics test (IS: 2720, Part-VII)

1.3 Objectives of study

- To study the compaction characteristics of soil.
- To determine the optimum mix of Cement Kiln Dust, Plastic Strips and expansive soil based on consistency limits test and compaction characteristics test.
- To check the variation of maximum dry density with optimum moisture content on addition of different proportions of Cement Kiln Dust and Plastic strips.

2. Results and Discussion

Physical properties of soil determined from this study are in the table below:

Table 2: 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

2.1 Consistency Limit Test on soil with Cement Kiln Dust (CKD): The variation of liquid limit, plastic limit and plasticity index with CKD is shown in table 3. Liquid limit and plastic limit test was performed for samples mixed with different percentage composition of CKD. Liquid limit and Plastic limit of the virgin soil was found out to be 53% and 28%. The LL and PI decrease with the addition of CKD up to 20% and then increase slightly with further increase in the addition of CKD. The initial reduction may be attributed to the cementitious properties of CKD due to high content of calcium oxide (CaO) which aids flocculation and aggregation of the soil particles. The increase in LL and PI beyond 20% CKD content is attributed to the extra water required to turn the soil-CDK mix to fluid. The PL of the soil increases with increase in CKD upto 20% and then decreases.

Table 3: Laboratory Test Results

Soil : CKD	Liquid limit (%)	Plastic Limit (%)	Plasticity Index (%)
100:0	53	28	25
90:10	49	28.8	20.2
85:15	47.8	29.5	18.3
80:20	46.6	30.1	16.5
75:25	47.4	29.2	18.2

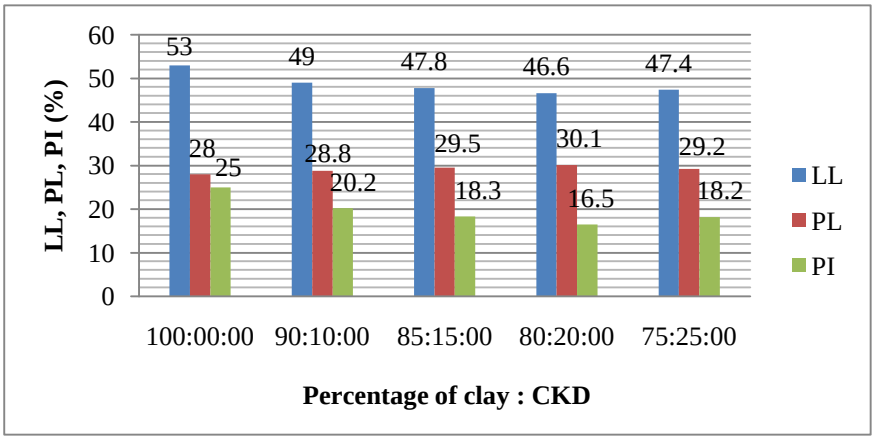

Fig 1: Consistency limit graph for various proportions

Fig 1 shows the consistency limits graph when different proportions of soil samples are treated with different amounts of CKD. When different amounts of CKD is added to the various proportions of soil sample, the liquid limit, plastic limit and the plasticity index show variations.

2.2 Compaction Characteristics: Moisture content and dry density relationship of virgin soil and soil mixed with different percentage of soil, CKD and Plastic strips were investigated by carrying out standard Proctor compaction test as per IS:2720 (part 7). The maximum dry density and optimum moisture content of various soil samples were determined.

Table 4: Standard Proctor test for clayey soil

Vol. of Mould (cm^3)	Moisture Content (%)	Dry Density (gm/cm^3)
1000	9.67	1.68
1000	10.02	1.76
1000	10.31	1.89
1000	11.23	1.78
1000	12.72	1.71

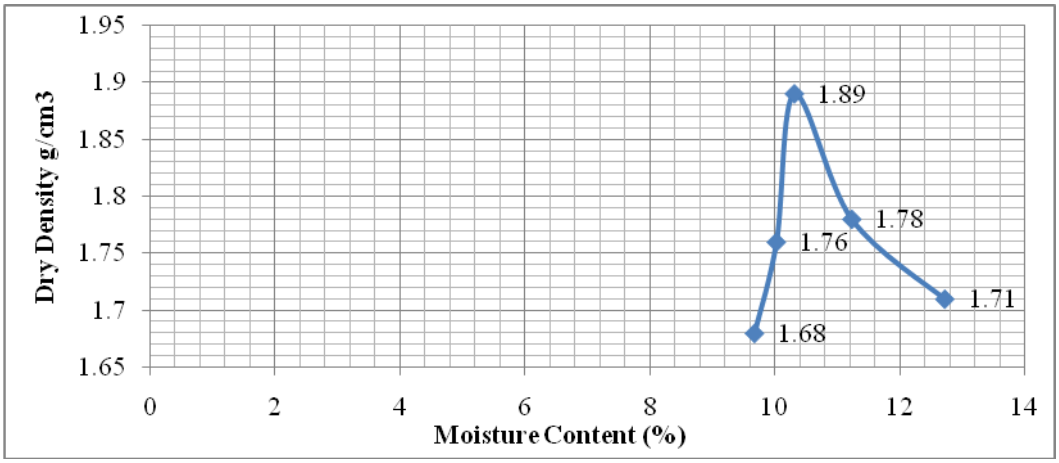

Fig 2: Variation of Dry Density with Moisture Content on Clayey Soil

Fig 2 shows the relationship between the dry density and moisture content. From the above figure we can calculate the Optimum Moisture Content and Maximum Dry Density of clayey soil used in the study. The OMC and MDD of the soil were found out to be 10.31% and 1.89 gm/cm^3 respectively.

Table 5: Variation of MDD and OMC Values of Various Mix Proportions

Soil: CKD: Plastic strips (%)	MDD (g/ml)	OMC (%)
100 : 0 : 0	1.89	10.31
89.5 : 10 : 0.5	1.82	11.81
84.5: 15 : 0.5	1.79	12.92
79.5 : 20 : 0.5	1.75	14.14
74.5 : 25 : 0.5	1.72	18.21
89: 10 : 1	1.69	20.54
84 : 15 : 1	**1.65**	**22.13**
79 : 20 : 1	1.67	20.12
74 : 25 : 1	1.71	17.92
88.5 : 10 : 1.5	1.76	16.21
83.5: 15 : 1.5	1.80	14.79
78.5 : 20 : 1.5	1.84	12.31
73.5 : 25 : 1.5	1.88	10.92

Table 5 shows the variation of OMC and MDD mix proportions. The Standard proctor test was performed for samples with various mixed proportion of Soil: CKD: Plastic strips to find out OMC and MDD. Samples were prepared by mixing CKD with different percentage at an interval of 5% and with Plastic strips percentage as 0.5%, 1% and 1.5%.

2.3 Moisture-Density Relationship

As the amount of Cement Kiln Dust content and Plastic strips increases the optimum moisture content increases and decreases the maximum dry density till optimum mix i.e. 84% of clay 15% of CKD 1% plastic strips. The MDD and OMC values for 100 % expansive soils are 1.89 g/ml and 10.31% respectively. The MDD and OMC for the optimum mix are 1.65 g/cc and 22.13%, respectively. The optimum mix is determined from the consistency's limit tests. The OMC increases due to extra water requirement for higher fineness and subsequent enhanced hydration. The MDD decreases due to flocculation of soil particles and due to the fact that in soil there is always a water content to produce maximum strength untreated.

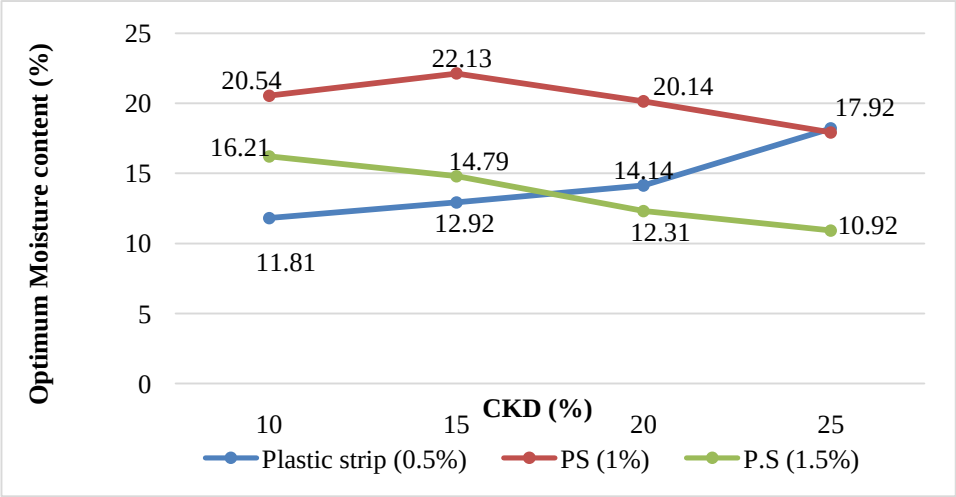

Fig 3: OMC v/s Percentage of CKD with 0.5%, 1%, 1.5% of Plastic strips with different proportions of Soil

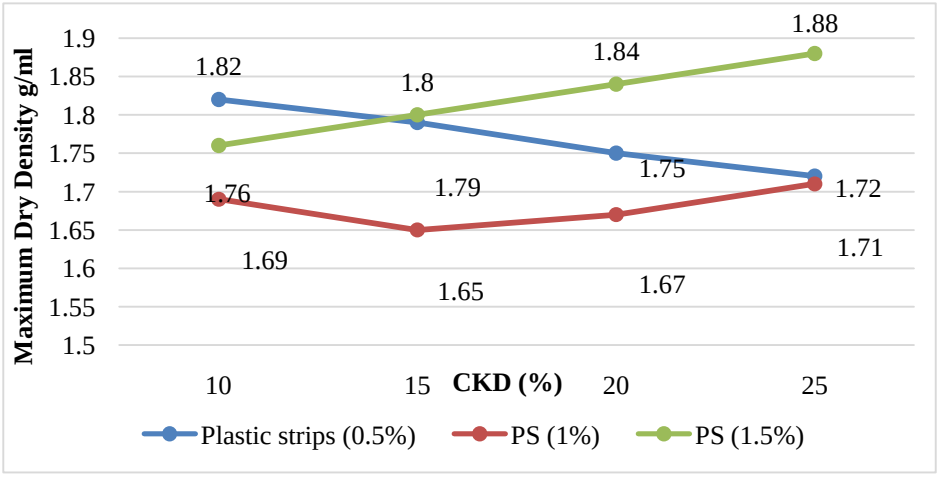

Fig 4: MDD v/s Percentage of CKD with 0.5%, 1%, 1.5% of Plastic Strips with different proportions of clay.

Figure 4 shows the maximum dry density of 0.5%, 1%, and 1.5% Plastic Strips at different proportions of CKD i.e. 10 %, 15 %, 20% and 25 %. As per the graph, 0.5% PS, the MDD value goes on decreases. In the 1% graph values decrease at 15 %, after that goes on increasing. In the case of 1.5% addition of PS values goes on sudden increase till 25 %.

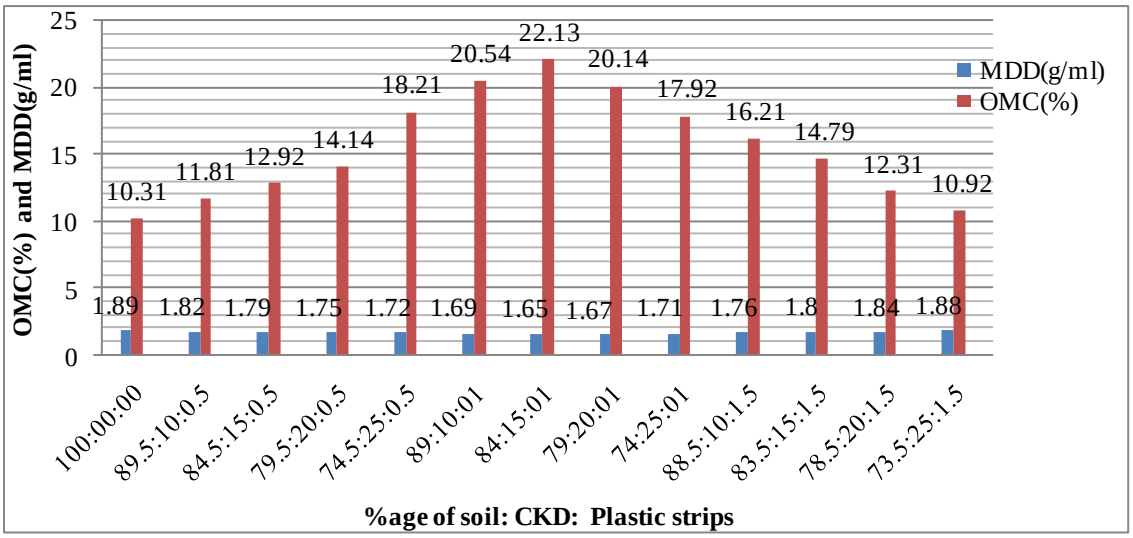

Fig 5: OMC % and MDD Values with Various Proportions CKD and Plastic Strips.

Fig 5 shows a graph in which OMC% shows gradual increase up to a certain point and then decreases. While the MDD goes on decreasing up to the same point and after that increases. The highest point in the graph is called Optimum moisture Content and Maximum Dry Density respectively.

3. CONCLUSIONS

- The optimum mix is found to be 84% soil, 15% CKD and 1% Plastic strips on the basis of compaction test.
- 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.
- 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.
- When CKD is used as soil stabilizing additive, Soil particles become large-sized clusters, resulting in texture change. The enlarged particle size causes the void ratio to increase. This increase in void ratio reflects the decrease in MDD and increase of moisture content for the Soil-CKD mixture.
- Increase in OMC is due to water held by flocculent water structure resulting from cementitious reaction.
- Using Plastic bottles as a soil stabilizer is an economical and gainful method since there is scarcity of good quality soil for embankments and fills.
- 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.
- This project is to meet the challenge of society to reduce the quantities of plastic wastes.

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