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Improvement of Pavement Soil Subgrade by using Cement Kiln Dust

Vikas Shukla[1], Dr. Sanjay Tiwari[2]
[1]*P.G. Student,* [2]*Professor, Department of Civil Engineering MITS Gwalior, Madhya Pradesh, India*

Abstract: ***The globally growing demand of cement results in huge production of Cement Kiln Dust. It is a waste by product of cement manufacturing industry. This material possess a health hazard ,storage problem and also is a pollution source .Utilizing such material in civil engineering works such as in modifying the soil subgrade would help to reduce some of these issues. To modify the engineering properties of the clayey soil, series of experiment were conducted to check the properties of soil blending with different percentage Cement kiln Dust as 5%, 10%, 15%, 20% and 25% by weight. Tests conducted for clayey soil mixed with Cement Kiln Dust were Liquid Limit, Plastic Limit, Free Swell Index, Optimum Moisture Content and Maximum Dry Density, and California Bearing Ratio, Unconfined Compressive Strength, Permeability. A comparison between properties of clayey soil and clayey soil mixed with Cement Kiln Dust is performed. It is reported that the engineering properties of clayey soil improved drastically with the varying percentage of cement kiln dust.***
Keywords: engineering properties, clayey soil, subgrades, cement kiln dust, California Bearing Ratio

I. INTRODUCTION

Industrial waste is a challenge in terms of the cost and safe disposal; the wastes that are unexplored are being researched upon to determine their suitability as road pavement material. Clayey soil on the other hand abounds in many parts of the world and its cover is around 3% world area.

In India the clay cover is around 20 % of its area, these soils are predominant in the states of Madhya Pradesh, Gujarat, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu. Clayey soil primarily composed of very small particles, and usually it contains silicates of aluminum and iron and magnesium.

Clayey soil also known by its expansive behavior and has got higher swelling and shrinkage property during dry and wet condition resulting in poor strength.

The concept of soil modification through stabilization with additives has been used from several thousand years (Fatani and Alzahrani 1991).The purpose of soil modification is to increase strength, reduce deformability ,provide volume stability ,reduce permeability and enhance durability of soil.

Soil modification involves the use of traditional techniques such as chemical stabilization by the addition of lime, class-C or class-f fly ash, Portland cement, rice husk ash. Industrial by products such as bagasse, brick kiln dust, cement kiln dust, steel or copper slag etc. Chemically modified soils often change surface molecular properties of the soil grains in certain cases, the grains are cemented together, resulting increase in strength and improvement of the engineering properties of soil.

In the manufacture of Portland cement, materials containing appropriate proportion of lime, silica, alumina and iron are mixed together .After blending, the prepared mix is fed into the upper end of a kiln .It passes through the kiln at a rate controlled by the slope of the kiln and the speed at which the kiln rotates. Burning fuel is forced into lower end of the kiln where it is produces temperatures of 1400 to 1650 degree Celsius, changing the raw mix to a cement clinker .The clinker is cooled and pulverized. During this operation a small percentage of the material in the form of dust, known as cement kiln dust (CKD), is collected and removed as an industrial waste. The accumulated waste is a source of concern for authorities because of health hazards also creates storage pollution problems. These problems call for urgent research for the use of local waste material as stabilizer in the field of construction work.

The use of Industrial waste in the area of soil stabilization is quite popular in present scenario. Generally industrial waste causes many serious environmental problems, so the utilization of industrial waste in construction industry is the best way to dispose it off. Using industrial waste in construction industry is beneficial in many ways such as disposal of waste, saving biodiversities, increasing soil properties like strength ,reduce permeability as well as preserving the natural soil and making economical structures.

II. MATERIAL USED

1) *Clayey Soil:* The soil used in this experiment is taken from the Malanpur, Bhind District of Madhya Pradesh. The soil collected from the site is brought to the laboratory for testing. Before testing it is assured that the soil is free from any organic matter, polythene etc. The soil collected is made oven dried for testing purpose .The soil is classified as clay of High plasticity CH with expansive behavior.

Table1. Properties of soil

Properties	Soil
Liquid limit (%)	38
Plastic limit (%)	22
Plasticity index (%)	16
Free swelling index (%)	45
Specific gravity	2..80
Natural moisture content (%)	17.1
Optimum moisture content (%)	18
Maximum dry density (KN/m^3)	16.81
CBR value (%)	1.51
Grain size distribution	
Gravel (%)	0
Sand (%)	(11.6 +.8) =12.4
Silt and Clay (%)	87.6

2) *Cement Kiln Dust (CKD):* Cement kiln dust is an industrial waste from cement production .CKD consists primarily of calcium carbonate and silicon dioxide which is similar to the cement kiln raw feed ,but the amount of alkalies, chlorides and sulphates is usually considerably higher in the dust .The CKD was obtained from the cement industries located in Rewa, Madhya Pradesh.

OXIDES	CaO	Al_2O_3	SiO_2	Fe_2O_3	Mn_2O_3	Na_2O	K_2O	Gs
Concentration	50.81%	4.71%	0	1.92	0.002	0.001	1.35	2.22

III. LABORATORY INVESTIGATION AND RESULT

In this research work experiments to determine the physical and mechanical properties of soil were conducted. According to Indian Standard Classification System (ISCS) the soil is classified. Liquid limit, plastic limit, plasticity index, specific gravity, free swelling index, standard proctor compaction, California bearing ratio tests were conducted on soil sample. Tests on treated soil sample are conducted after seven days of curing.

Result of soil sample after replacement from CKD

A. Free Swell Index Value For Mix Proportions Of Soil And Cement Kiln Dust

Free Swell Index	Mix Proportion	Clayey soil	5% CKD	10% CKD	15%CKD	20% CKD	25 %CKD
1	Initial Volume	10 ml	10 ml	10 ml	10 ml	10 ml	10 ml
2	Final Volume	13.1 ml	12.8 ml	12.5 ml	12.1 ml	11.5 ml	10.5 ml
3	Free Swell Index	31	28	25	21	15	5

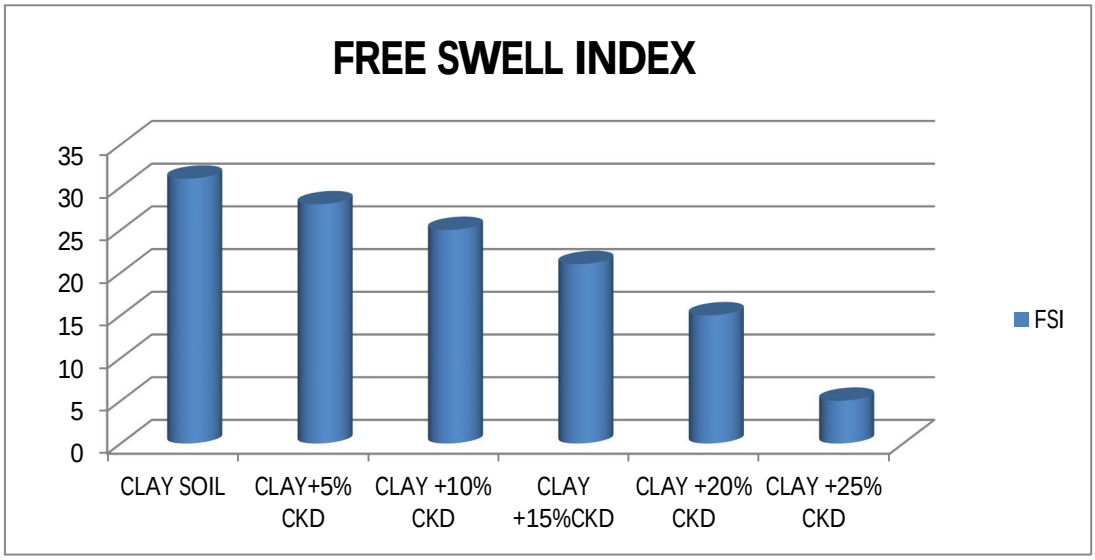

Fig1. Chart showing the variation in Free Swell Index for mix proportions of soil and cement kiln dust

B. Compaction Test value for mix proportions of soil and cement kiln dust (CKD)

Content	Clayey Soil	5% CKD	10% CKD	15% CKD	20% CKD	25% CKD	30% CKD
MDD(KN/m^3)	16.81	17.52	18.22	19.30	19.60	20.50	19.80
OMC (%)	18.00	16.70	15.93	13.40	12.43	10.94	11.45

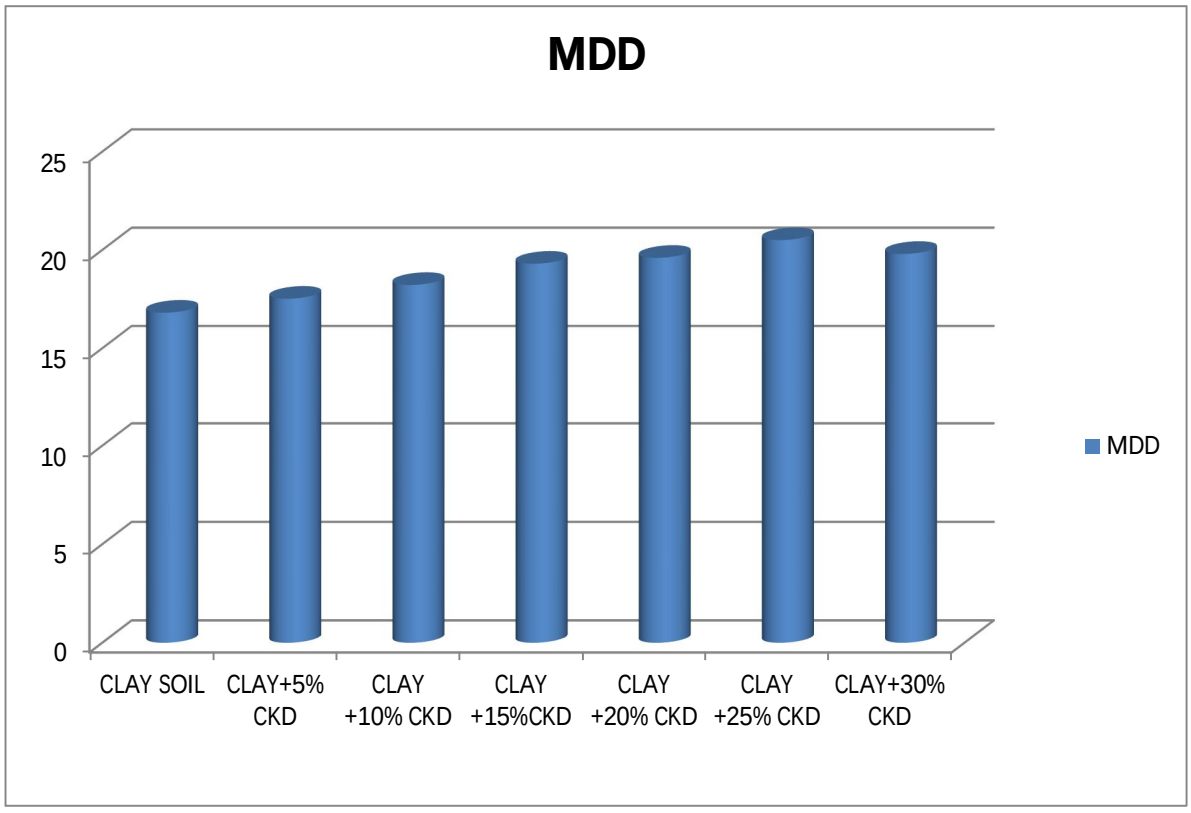

Fig.2 (a). Chart showing the variation in MDD for mix proportion of Soil with cement kiln Dust(CKD)

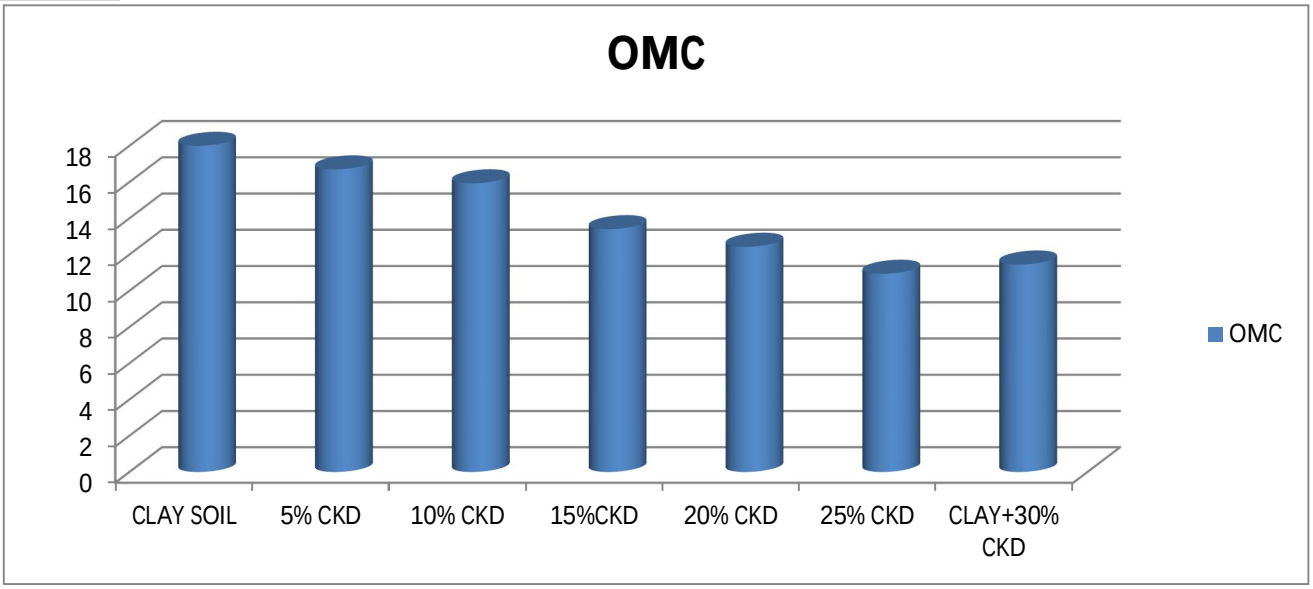

Fig.2 (b). Chart showing the variation of OMC for mix proportion of soil with cement kiln dust (CKD)

C. CBR Value for mix proportions of soil and Cement Kiln Dust (CKD)

Percentage of CKD	CBR % at 2.5 mm penetration	CBR % At 5mm penetration
Clayey soil	1.51	1.3
5 % CKD	1.75	1.4
10 % CKD	1.83	1.46
15 % CKD	2.03	1.59
20 % CKD	2.82	2.2
25% CKD	3.54	3.45

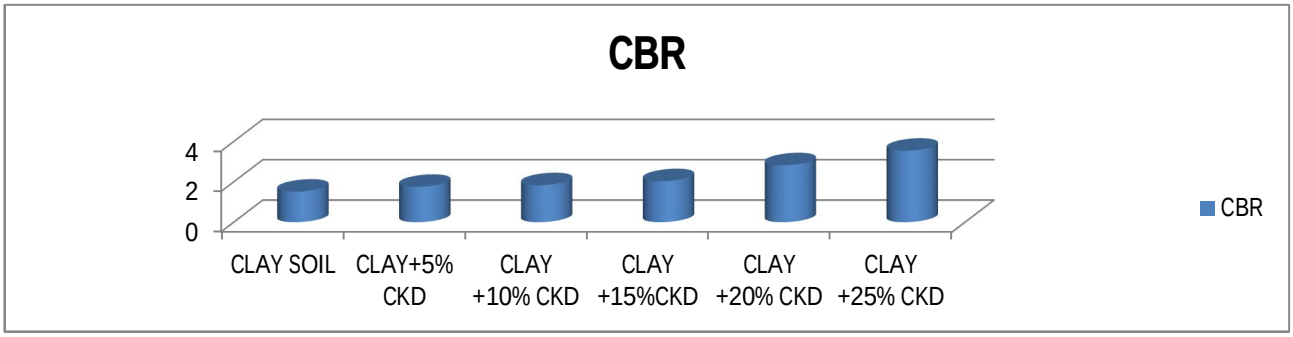

Fig3. Chart showing the variation of CBR for mix proportion of soil with cement kiln dust (CKD)

D. UCS Value for mix proportion of soil and Cement kiln Dust (CKD)

Test	Clayey soil	5% CKD	10% CKD	15% CKD	20 % CKD	25 % CKD
UCS	140 KN/m^2	151 KN/m^2	155.5 KN/m^2	163 .1KN/m^2	170 KN/m^2	178 KN/m^2

E. Variation of permeability for mix proportion of soil and Cement kiln Dust

Test	Clayey soil	5% CKD	10% CKD	15% CKD	20 % CKD	25% CKD
Permeability (cm/s)	4.80×10^{-4}	6.65×10^{-4}	9.08×10^{-4}	9.95×10^{-4}	1.30×10^{-4}	1.43×10^{-4}

IV. CONCLUSION

In this study, the soil is replaced with Cement kiln dust of different percentages (5%, 10%, 15%, 20% and 25%) and tests are performed after seven days of curing. From free swelling index, optimum moisture content (OMC) and maximum dry density (MDD), CBR test results are conclude as:

A. The experimental results conclude that with the increment in the percentage of Cement Kiln dust in clayey soil decrement in the swelling potential of soil takes place. When the replacement of soil reached 25% the swelling of soil is restricted only about 5%.

B. With the increment in percentage of cement kiln dust, the optimum moisture content (OMC) decreases and maximum dry density (MDD) increases upto 25% replacement. The optimum moisture content (OMC) and maximum dry density (MDD) at 25% replacement of soil cement kiln dust is 10.94% and 20.50 KN/m^3.Further increment in the percentage of ckd reduce the dry density and increases the optimum moisture content.

C. With the increment in the percentage of cement kiln dust increasing trend of CBR is also observed. At 25% replacement of soil with ckd the CBR value is 3.54 percent which is almost the double as compared to the raw soil CBR value.

D. The unconfined compressive strength also increases with the varying percentage of cement kiln dust and its value increased from140 KN/m^2 to 178 KN/m^2witht 25% replacement of ckd with the soil.

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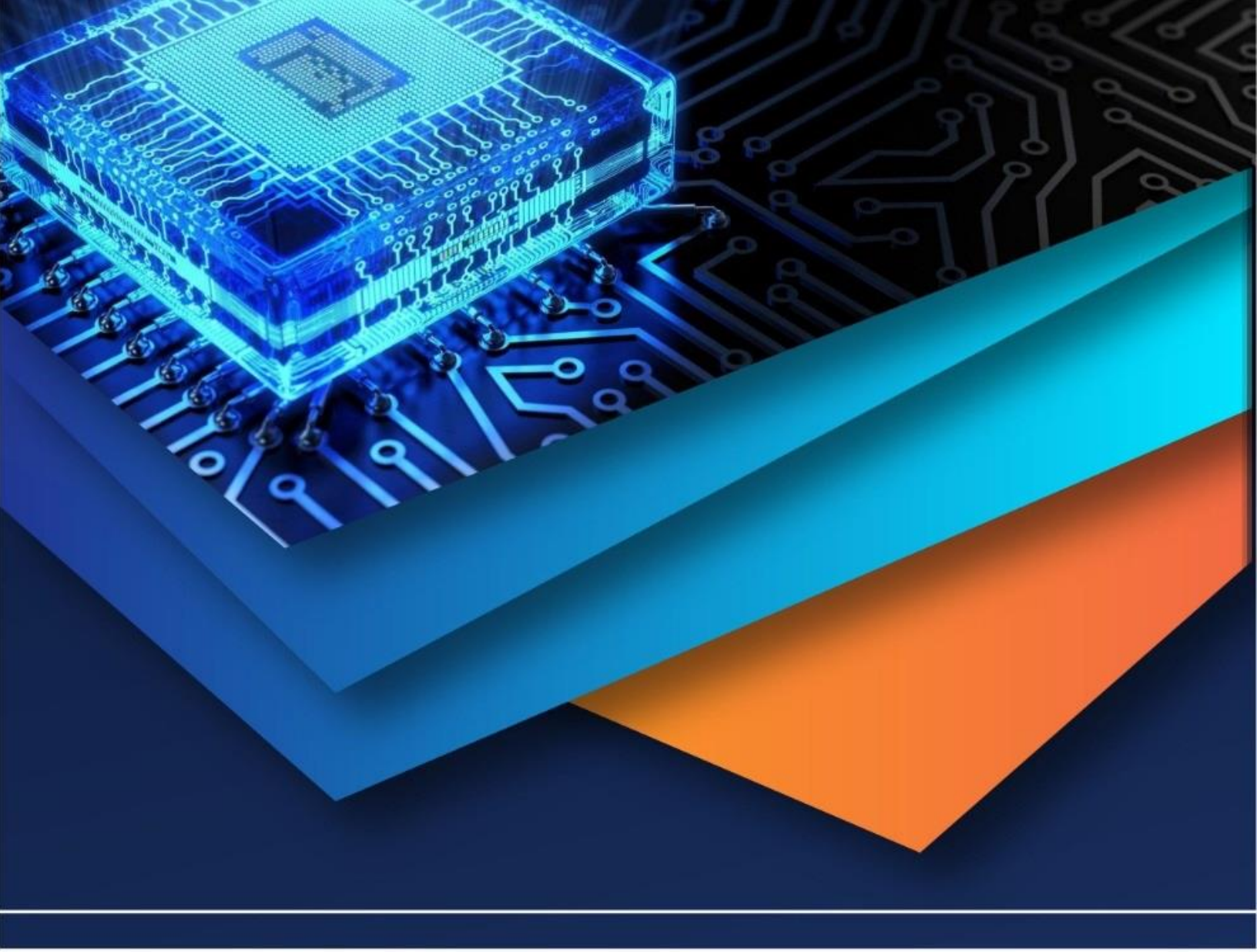

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