A Comparative Study on Cement Kiln dust Stabilized Expansive Soil with Plastic Waste and Sodium Chloride

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Abstract— A large number of infrastructure projects are being installed in almost every part of our country .The wastes of industries and agriculture adversely affect the environment as high land area will be required for their disposal and when they disintegrate, results in the production of harmful gases causing, soil contamination, land fill space and many other hazardous effects. In India, the rate of generation of solid waste is found to be increasing at a very rapid rate in past few years. Soil stabilization is a process that improves the engineering properties of soil such as strength, volume stability and durability. Expansive soils are those whose volume changes significantly when it comes in contact with water and are therefore, problematic to structures. Extensive laboratory trials have been carried out by various researchers and had shown promising results for application of such expansive soil after stabilization with additives such as sand, silt, lime, fly ash, etc. The present study was planned to compare and evaluate the influence of Plastic waste and Sodium chloride in varying percentage to further improve the expansive soil replaced with optimum Cement Kiln Dust percentage. Laboratory tests will be carried out and results are analyzed & reported.

Key words: Plastic Waste and Sodium Chloride, CKD, CBR

I. INTRODUCTION

The need to bring down the growing cost of soil stabilizers and the cost of waste disposal has lead to intense global research towards economic utilization of wastes for engineering purposes. The safe disposal of industrial and agricultural waste products demands urgent and cost effective solutions because of the debilitating effect of these materials on the environment and to the health hazards that these wastes constitute. The over dependence on industrially manufactured soil improving additives (cement, lime etc.) have kept the cost of construction of stabilized road financially high.

Cement kiln dust is a by-product in the production of Portland cement clinker. Disposal of cement kiln dust is an environmental problem. The utilization of this waste material has received increasing attention because it not only solves a potential solid waste problem but also provides an alternative stabilizing agent using in chemical stabilization of problematic soils and provides an alternative construction material. The use of the cement kiln dust for chemical stabilization applications may be an environmental solution of the problems associated with its disposal process where a very huge amount of the cement kiln dust as by-product is daily produced from the cement factories in Egypt. The composition of the cement kiln dust is similar to raw materials of cement but the amount of alkalis, chlorides and sulfates is usually considerably higher in the cement kiln dust.

A. Objectives of the Study

The objectives of present experimental study are as follows.

- To identify the strategy of techniques to overcome the problems posed by expansive soil with a view to adopt suitable methodology through critical review of literature.
- To evaluate the performance of expansive soil when stabilized with proposed additives and admixtures.
- To investigate the suitability and adoptability of Waste plastics as discrete reinforcement.
- To investigate the suitability and adoptability of Sodium Chloride as Bonding through chemical reaction.

II. LITERATURE REVIEW

The basic and primary problem that originates with regard to expansive soils is that elastic deformations are significantly less than that type of soils' deformations and the predictions about that cannot be made by classical elastic or plastic theory.

CKD "is particulate matter that is collected from cement kiln exhaust gases and consists of entrained particles of clinker, un reacted and partially calcined raw materials, and fuel ash enriched with alkali sulfates, halides and other volatiles" (Sreekrishnavilasam, et al., 2006). 35 The chemical and physical properties of CKD can be influenced by several factors. Because plant operations differ considerably with respect to raw feed, type of operation, dust collection facility, and type of fuel used, the use of the terms typical or average CKD when comparing different plants can be misleading. The dust from each plant can vary markedly in chemical, mineralogical and physical composition (Keerthi, et al., 2013). A number of CKDs and clay-type soils were used in order to study the soil stabilization. Soil- CKD mixes including 3, 8, and 10 % of CKD were tested for various engineering properties like the unconfined compressive strength, moisture density relationship, liquid limits (LL), plastic limit (PL), plasticity index (PI), and shrinkage limit (Rahman, et al., 2011). Compared to lime, the increase in CBR (California Bearing ratio) due to CKD was much greater; however, lime is proved to be better at reducing the PI, giving a PI reduction from 28 % to nearly 0 % at 5 % lime content. The available literature indicates that at given the proper conditions, CKD can be an effective soil stabilizer (Miller & Azadb, 2000). It has been displayed that incorporation of the cement kiln dust induced extensive changes in the physico-chemical properties of Na-montmorillonite clay. The strength of CKD-treated and moist-compacted Na-montmorillonite clay specimens increased substantially even after one day, and progressively with further curing (Peethamparan, et al., 2009). Ismaiel (2013) states that CKD having self-cementing characteristics

reacts with soil in a manner similar to Portland cement. Typically, CKD has approximately one-third of the amount of cement oxides (CaO, Al2O3, SiO2, and Fe2O3) present in Portland cement. The primary value of cement kiln dust (CKD) is its cementitious property. Depending on the concentration of free lime (CaO), CKD can be highly cementitious.

III. METHODOLOGY

A. Expansive Soil

The Clay that has been used in this study was a typical BC soil collected from Yanam, East Godavari District. The soil used for the investigation was dried, pulverized and then sieved through 4.75mm size sieve. The properties of black cotton soil experimented, based on relevant I.S. code provisions are given in the Table 1 below.

S.N	Property	Value
1	Grain Size Distribution	
	Sand %	3
	Silt %	35
	Clay %	62
2	Atterberg Limits	
	Liquid Limit %	66.6
	Plasti Limit %	33.2
	Plasticity Index %	33.4
3	Compaction Properties	
	Optimum Moisture Content %	20.5
	Maximum dry density %	1.38
4	Specific Gravity	2.52
5	IS Classification	CH
6	Soaked CBR %	1.6
7	Differential Free Swell %	140
8	Unconfined Compressive Strength	84.2

Table 1: Physical properties of Expansive Soil

B. Cement Kiln Dust

Cement kiln dust is created in the kiln during the production of cement clinker. The dust is a particulate mixture of partially calcined and unreacted raw feed, clinker dust and ash, enriched with alkali sulfates, halides and other volatiles. These particulates are captured by the exhaust gases and collected in particulate matter control devices such as cyclones, baghouses and electrostatic precipitators (Figure 1). Several factors influence the chemical and physical properties of CKD. Because plant operations differ considerably with respect to raw feed, type of operation, dust collection facility, and type of fuel used, the use of the terms typical or average CKD when comparing different plants can be misleading. The dust from each plant can vary markedly in chemical, mineralogical and physical composition

Constituent	% by weight		Constituent	% by weight
$CaCO_3$	55.5		Fe_2O_3	2.1
SiO_2	13.6		KCl	1.4
CaO	8.1		MgO	1.3
K_2SO_4	5.9		Na_2SO_4	1.3
$CaSO_4$	5.2		KF	0.4
Al_2O_3	4.5		Others	0.7

Table 2: Typical Composition of Cement Kiln Dust

C. Plastic Waste

Plastic used in this study are disposal cement plastic bags. It has low weight and ease of transportation and very low impermeability. The disposal of waste plastic cement bags used in this study collected from CIT gubbi campus. By collecting this plastic bags are cut in to the pieces. The thickness of the plastic strips consists of 10µ. The length and breadth of the plastic strip is 3mm*20mm.

Sodium chloride is white in colour and is in the form of crystals. It is deliquescent and hygroscopic. It lowers the vapour pressure of water. It also reduces or prevents frost heave in soil by lowering the freezing point of water. It is very effective as dust palliative. It checks the formation of shrinkage cracks. Sodium chloride is extensively used in many chemical industries. It is also widely used in metal treating, water softening, Markets etc.

IV. RESULTS AND DISCUSSIONS

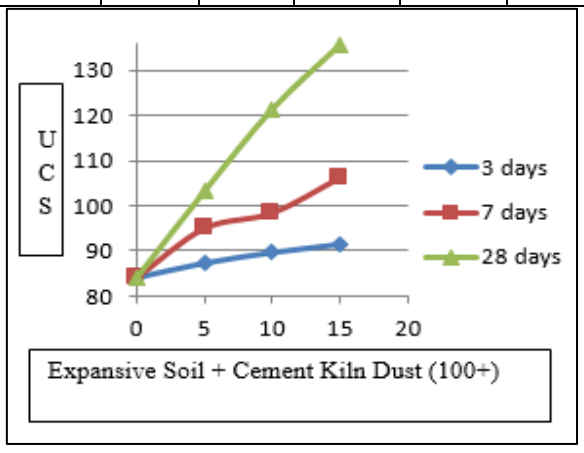
In the laboratory, various experiments were conducted by adding different percentages of metakaolin in the problematic expansive Soil and also further stabilizing it with Nacl and waste plastic as a binder for comparision. Liquid Limit, Plastic Limit and Compaction, CBR and Triaxial shear tests were conducted with a view to determine the optimum combination of Cement Kiln Dust as replacement in problematic expansive Soil and Nacl and waste plastic as a binder and reinforcement. The influence of the above said materials on the Index are studied.

A. Variation of OMC & MDD of Expansive Soil with Cement Kiln Dust

ES + CKD	OMC %	MDD %
100+0	20.5	1.38
95+5	21.8	1.44
90+10	23	1.49
85+15	24.2	1.53

B. Variation of Unconfined Compressive Strength, Cohesion and California Bearing Ratio of Expansive Soil with Cement Kiln Dust

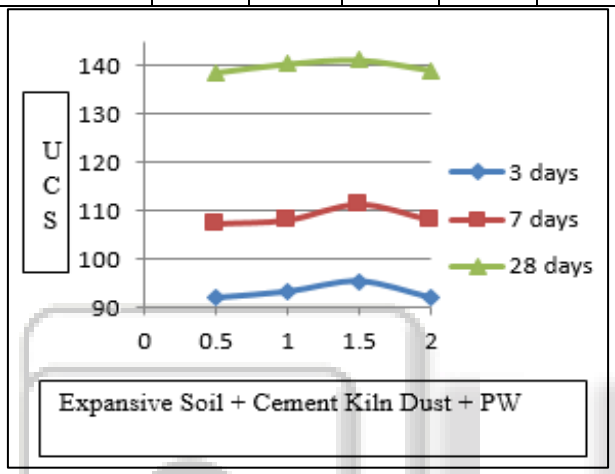
ES + CKD	UCS			C_u KPa	CBR %
	3 days	7 days	28 days		
100+0	84.2	84.2	84.2	40.15	1.6
95+5	87.4	95.1	103.3	49.72	2.39
90+10	89.7	98.5	121.4	58.63	3.28
85+15	91.5	106.3	135.6	65.54	4.05



Plot Showing Variation of Unconfined Compressive Strength for Expansive Soil with Cement Kiln Dust

C. Variation of Unconfined Compressive Strength, Cohesion and California Bearing Ratio of Expansive Soil with Cement Kiln Dust and addition of different % of Plastic waste

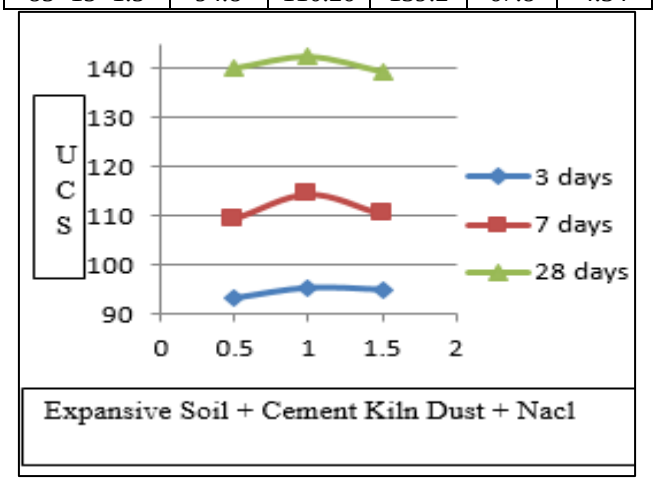
ES + CKD+PW	UCS			C_u KPa	CBR %
	3 days	7 days	28 days		
85+15+0.5	92	107.2	138.6	67.54	4.25
85+15+1	93.2	108	140.4	68.12	4.32
85+15+1.5	95.3	111.4	141.2	71.2	4.5
85+15+2	92	108	139.1	65.2	4.39



Plot Showing Variation of Unconfined Compressive Strength for Expansive Soil with Cement Kiln Dust further blended with Waste plastic

D. Variation of Unconfined Compressive Strength, Cohesion and California Bearing Ratio of Expansive Soil with Cement Kiln Dust and addition of different % sodium chloride

ES + CKD+PW	UCS			C_u KPa	CBR %
	3 days	7 days	28 days		
85+15+0.5	93	109.35	140	68	4.15
85+15+1	95.2	114.5	142.6	71.6	4.34
85+15+1.5	94.8	110.26	139.2	67.8	4.34



Plot Showing Variation of Unconfined Compressive Strength for Expansive Soil with Cement Kiln Dust further blended with Sodium Chloride

V. Conclusions

The following conclusions are made based on the laboratory experiments carried out in this investigation.

- From the laboratory studies, it is observed that the Expansive Soil chosen was a problematic soil having high swelling, and high plasticity characteristics.
- It was observed that the treatment as individually with 15% CKD has moderately improved the expansive soil.
- There is a gradual increase in maximum dry density with an increment in the % replacement of CKD.
- There is an improvement in maximum dry density and also corresponding strength characteristics with an increase in the waste plastic content from 0% to 2%.
- There is an improvement in maximum dry density and also corresponding strength characteristics with an increase in the sodium chloride content from 0% to 1.5%.
- It is evident that the addition of cement Kiln Dust CKD to the Expansive soil showed an improvement in compaction, strength and penetration characteristics to some extent and on further blending it with Waste Plastic and Sodium Chloride, the strength mobilization was more pronounced.
- Finally it can be showed by comparing the results of CKD stabilized expansive soil with WP as well as Nacl, CKD stabilized expansive soil with Nacl gives better results than CKD stabilized expansive soil with WP.

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