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Comparative Study on Behaviour of Soft Soil Using Various Admixtures

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ABSTRACT: *Low bearing capacity and high settlement behaviour of expansive soils is the challenge for the engineers to work on it. But today, there are number of techniques available to control/improve the undesired properties of soil. The paper reviews the performance of different characteristics of soil on insertion of various admixtures like Cement Kiln Dust (CKD), RBI Grade 81, Rice Husk Ash (RHA) and Fly Ash. In this paper, an attempt is made to analyse and evaluate the index properties as well as the engineering properties of soil like plasticity, compaction, unconfined compressive strength and California bearing ratio. It was concluded that the consistency limits decreases with the addition of fly ash, CKD, RHA & RBI Grade 8. The unconfined compressive strength & CBR value of treated soil mixture increases with the increase in percentage of CKD and RBI Grade 81.*

Keywords: *Soil Stabilization, Cement Kiln Dust, RBI Grade 81, Rice Husk Ash & Fly Ash.*

I. INTRODUCTION

Expansive soils are mostly found in the arid and semi-arid regions and it covers very large area of the world. It covers nearly 20% of the landmass in India and includes Western Madhya Pradesh, parts of Gujarat, Andhra Pradesh, Uttar Pradesh, Karanataka, and Maharastra. Soft soils show major volume changes due to change in the moisture content. This causes major damage to property constructed on it. These soils contain minerals such as montmorillonite that are capable of absorbing water. When they absorb water their volume increases. Although mechanical compaction, dewatering and earth reinforcement have been found to improve the strength of the soils, other methods like stabilization using admixtures are more advantageous. Soil stabilization is referred to as a method in which a soil is proportioned/added or removed, or an industrial waste products or other binder chemical material is added to a natural soil material to improve one or more of its properties. One of the inexpensive methods of stabilization includes the mixing of natural coarse-grained soil and fine-grained soil to obtain a mixture that develops good internal friction and cohesion and thereby provides a material that is ease during placement but will remain stable further. Improvement of soil property by proportioning of coarse and fine grained soil is commonly referred to as mechanical stabilization. On the other hand stabilization can also be achieved by mechanically mixing the natural soil stabilizing material together so as to obtain a homogeneous mixture. After the soil and the stabilizing agent are mixed and worked together, they are compacted using an appropriate compaction energy applicant. The stabilizing materials include cement, lime, fly ash, bitumen/asphalt, polymers and other chemical. Addition of chemicals causes a physico-chemical alteration and referred to as chemical stabilization. In order to increase the stabilization, additives which have the properties of water-holding or water-resisting property are sometimes added.

II. LITERATURE REVIEW

[1]**S. R. Gandhi (2005)** presented a paper to describe a study carried out to check the improvements in the properties of expansive soil with fly ash in varying percentages. Both laboratory trials and field tests have been carried out and results are reported in this paper. One of the major difficulties in field application is thorough mixing of the two materials (expansive soil and fly ash) in required proportion to form a homogeneous mass. The paper describes a method adopted for placing these materials in layers of required thickness and operating a “Disc Harrow”. A trial embankment of 30m length by 6m width by 0.6m high was successfully constructed and the in-situ tests carried out proved its suitability for construction of embankment, ash dykes, filling low-laying areas, etc. [2]**Wayne S. Adaska et al. (2008)** studied about the significant by product material of the cement manufacturing process i.e. Cement kiln dust (CKD). This paper discussed the basic characteristics of CKD including current production status and regulatory requirements. Beneficial commercial uses are then presented covering a wide variety of applications including agricultural soil enhancement, base stabilizing for

pavements, wastewater treatment, waste remediation, low-strength backfill and municipal landfill cover. [3]**A K Singhai and R K Yadav (2014)** studied about the feasibility of using Rice Husk Ash with lime as soil stabilization material. A series of laboratory experiment has been conducted on 5% lime mixed black cotton soil blended with Rice Husk Ash in 5%, 10% 15% and 20% by weight of dry soil. The experimental results showed a significant increase in CBR and UCS strength. The CBR values increases by 287.62% and UCS improved by30%.The Differential free swell of the black cotton soil is reduced by 86.92% with increase in Rise Husk Ash content from 0% to 20% respectively. From this investigation it can be concluded that the Rice Husk Ash has a potential to improve the characteristics of black cotton soil. [4]**J. Sudheer Kumar & Upma Janewoo (2016)** in their study they use cement kiln dust as an admixture to stabilize the clayey soil. Clayey soil for the work was collected from Sundernagar, Distt. Mandi (HP), India and the Cement kiln dust was collected from ACC cement factory, Barmana (HP), India. They prepare a mixture of CKD and RBI Grade 81 with clayey soil altogether mixed with hand at dry state. Required amount of water shall be added, mixed with the proportion at least for 6 min and squeezed out the air. The optimum moisture content and maximum dry density of the each mix were determined by the standard Proctor test. The specimens were prepared for UCS test with the length to diameter ratio of 2 (38 mm diameter and 76 mm length). Cylindrical specimen was prepared with static compaction with optimum moisture content. The specimens kept in desiccators until testing of 3, 14 and 28 days of curing. Three specimens were prepared for each mixture. The sample was prepared for the CBR test in the specified mould with the specifications of standard proctor test. The CBR test was carried out with the help of plunger of 50 mm diameter. The CBR value calculated corresponding to 2.5-mm penetration.

III. MATERIALS USED

Materials used in the present work are described below:

1.1 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, bag houses and electrostatic precipitators[2]. Table 3.1 represents the composition of CKD.

1.2 RBI Grade 81: Road Building International (RBI) Grade 81 is a powder that is composed of a number of naturally occurring compounds. It is an odorless beige powder. The pH of saturated paste is l2.5. It improves the structural properties of a wide range of soils. It is particularly effective with silty-clayey soil with low geo-mechanical qualities. RBI Grade 81 works by hydration reaction. Table 3.2 represents the composition of RBI Grade 81.

1.3 Rice Husk Ash (RHA): Rice Husk is an agricultural waste obtained from milling of rice. Rice husk ash, basically a waste material, is produce by rice - mill industry while processing rice from paddy. Rice husk ash is a pozzolanic material that could be potentially used in soil stabilization, though it is moderately produced and readily available. About 20- 22% rice husk is generated from paddy and about 25% of this total husk become ash when burn. It is non-plastic in nature. RHA has a good pozzolanic property. The chemical properties of RHA are shown in Table 3.3

1.4 Fly Ash: Fly ash is one of the residues created during the combustion of coal in coal-fired power plants. Fly ash by itself has little cementatious value but in the presence of moisture it reacts chemically and forms cementatious compounds and attributes to the improvement of strength & compressibility characteristics of soils. Fly ash is a fine, glass powder recovered from the gases of burning coal during the production of electricity. These micron-sized earth elements consist primarily of silica, alumina and iron. Table 3.4 represents the composition of fly ash.

IV. RESULTS AND DISCUSSION

1.1 Cement Kiln Dust-Soil Stabilization: A comparison is made between the index and engineering properties of soil with and without admixtures. Table 4.1 gives the effect of CKD on the consistency limits, Maximum dry density (MDD) and the optimum moisture content (OMC) of the soil. It has been observed that the consistency limits and the MDD value of the soil with the addition of CKD has reduced. Whereas OMC value has increased on addition of CKD to the soft soil.

1.2 Road Building International (RBI) Grade 81-Soil Stabilization: Table 4.3 shows the value of the consistency limits, MDD (maximum dry density) and OMC (optimum moisture content) with RBI Grade 81. These tests are performed with three different ratios of RBI Grade 81 mixed clayey soil (i.e. 100% clay, 95% clay + 05% RBI Grade 81, 90% clay + 10% RBI Grade 81 & 85% clay + 15% RBI Grade 81). The MDD (maximum dry density) of natural soil sample was 1.80 g/cc and the MDD for a clayey soil with 5%, 10% & 15% RBI Grade 81 content were 1.75, 1.72 & 1.70 g/cc, this means MDD decreases with increasing content of RBI Grade 81 and OMC values slightly increases with adding of RBI Grade 81. The MDD decreased because of decrease in specific gravity of the reconstituted due to increase in RBI Grade 81 content. Flocculation and Agglomeration process of stabilization is the reason behind the decrease in the value of dry density.

1.3 Rice Husk Ash- Soil Stabilization: Atterberg limits & compaction tests performed with clayey soil with varying rice husk ash contents 0%, 5%, 10% & 15 %, and their results are shown in table 4.5. The value of liquid limit (LL) & plastic limit (PL) increases with increasing rice husk ash content. The increase in trend of Atterberg's limit is due to increase in more fines and activity of the material. A possible explanation of the results may be related to the mixing of rice husk ash content, which facilitates flocculation and agglomeration of the clay particles. Increment of OMC was probably produced by the fineness of rice husk ash compared to that of natural soil, which caused an enlarged void ratio in soil mixtures or the optimum moisture content of soil increases with increase rice husk ash content. The specific surface area of a particle increases and more water content required.

1.4 Fly ash- Soil Stabilization: From table 4.8, it concludes that the California bearing ratio (soaked) value & unconfined compressive strength value of pure clayey soil is slightly less than to the values of fly ash mixed clayey soil, which means these values increases with the increasing of flash content from 0% to 15%. The California bearing ratio value is 1.89% pure clayey soil and 4% for fly ash mixed clayey soil (15% F.A). The CBR value for fly ash mixed clayey soil increases with an average of 2.11%. Due to the pozzolanic material, load carrying capacity is slightly increased. The MDD (maximum dry density) of natural soil sample was 1.71 g/cc and the MDD for a clayey soil with 5%, 10% & 15% fly ash content were 1.70, 1.69 & 1.68 g/cc, this means MDD decreases with increasing content of fly ash. The decrease in the value of dry density because flocculation and agglomeration change the texture of the mixed soil and due to which it cover large space into the soil particles and increase water holding capacity.

V. FIGURES AND TABLES

Table 3.3: Composition of Rice Husk Ash

Oxide Compounds	Content (%)
SiO_2	85.14
Al_2O_3	2.07
Fe_2O_3	1.43
CaO	3.05
MgO	4.03
Loss on ignition	4.28

Table 3.4: Composition of Fly ash

Oxide Compounds	Content (%)
SiO_2	53.12
Al_2O_3	29.58
Fe_2O_3	05.32
CaO	2.82
MgO	0.73
K_2O	1.20
Na_2O	0.34
TiO_2	1.05
Loss on ignition	5.84

Table 3.1: Composition of Cement Kiln Dust

Oxide Compounds	Content (%)
CaO	55.06
SiO_2	11.90
Al_2O_3	9.90
Fe_2O_3	3.40
SO_3	1.48
MgO	1.70
Na_2O	0.50
K_2O	0.10
Loss on ignition	4.70

Table 3.2: Composition of RBI Grade 81

Oxide Compounds	Content (%)
CaO	52-56
SiO_2	15-19
Al_2O_3	5-7
Fe_2O_3	0-2
SO_3	9-11
MgO	0-1
Mn, K, Cu, Zn	3
Fibres	1
Additives	0-4

Table 4.1 Effect of CKD on Consistency limits, MDD & OMC of expansive soil

SOIL : CKD	LL (%)	PL (%)	PI (%)	MDD (g/cc)	OMC (%)
100 : 00	64	31.7	32.3	1.68	20
95 : 05	54.2	31.3	22.9	1.67	21.5
90 : 10	52.5	31	21.5	1.65	22
85 : 15	55.9	31.5	24.0	1.64	24

Table 4.2 Effect of CKD on CBR & UCS value of soil at different curing periods

SOIL : CKD	CBR (%)	UCS (kPa) 3 Days curing	UCS (kPa) 14 Days curing	UCS (kPa) 28 Days curing
100 : 00	1.65	88.3	88.3	88.3
95 : 05	2.41	91.2	99.2	107.5
90 : 10	3.88	93.9	102.5	125.7
85 : 15	4.35	95.8	111.5	139.5

Table 4.3 Effect of RBI Grade 81 on Consistency limits, MDD & OMC of expansive soil

SOIL : RBI	LL (%)	PL (%)	PI (%)	MDD (g/cc)	OMC (%)
100 : 00	49.14	28.78	14.05	1.80	16.50
95 : 05	46.80	30.18	16.62	1.75	17.55
90 : 10	44.75	32.32	12.43	1.72	17.26
85 : 15	43.35	33.12	10.23	1.70	17.06

Table 4.4 Effect of RBI Grade 81 on CBR & UCS value of soil at different curing periods

SOIL : RBI	CBR (%)	UCS (kPa) 3 Days curing	UCS (kPa) 14 Days curing	UCS (kPa) 28 Days curing
100 : 00	2.55	133.4	133.4	133.4
95 : 05	5.10	203.1	239.3	257.0
90 : 10	6.56	269.2	320.7	329.6
85 : 15	8.02	349.3	371.7	374.7

Table 4.5 Effect of RHA on Consistency limits, MDD & OMC of expansive soil

Soil : RHA	LL (%)	PL (%)	PI (%)	MDD (g/cc)	OMC (%)
100 : 00	46	22	24	1.56	21.5
95 : 05	50	27	23	1.49	22.5
90 : 10	55	34	21	1.42	27.0
85 : 15	57	37	20	1.40	32.0

Table 4.6 Effect of RHA on CBR & UCS value of soil at different curing periods

Soil : RHA	CBR (%)	UCS (kPa) 0 Days curing	UCS (kPa) 03 Days curing	UCS (kPa) 07 Days curing
100 : 00	1.55	60.0	60.0	60.0
95 : 05	2.15	172.0	189.0	201.3
90 : 10	3.00	255.0	270.3	288.4
85 : 15	2.80	210.0	235.5	256.0

Table 4.7 Effect of Fly Ash on Consistency limits, MDD & OMC of expansive soil

Soil : Fly Ash	LL (%)	PL (%)	PI (%)	MDD (g/cc)	OMC (%)
100 : 00	59.77	27.54	32.32	1.71	20.85
95 : 05	56.26	32.04	27.22	1.70	20.00
90 : 10	54.06	33.51	23.55	1.69	19.58
85 : 15	52.38	35.07	17.31	1.68	19.50

Table 4.8 Effect of Fly Ash on CBR & UCS value of soil at different curing periods

Soil : Fly Ash	CBR (%)	UCS (kPa) 0 Days curing	UCS (kPa) 3 Days curing	UCS (kPa) 07 Days curing
100 : 00	1.89	455	455	455
95 : 05	2.10	455	490	525
90 : 10	2.50	456	508	560
85 : 15	4.00	457	514	570

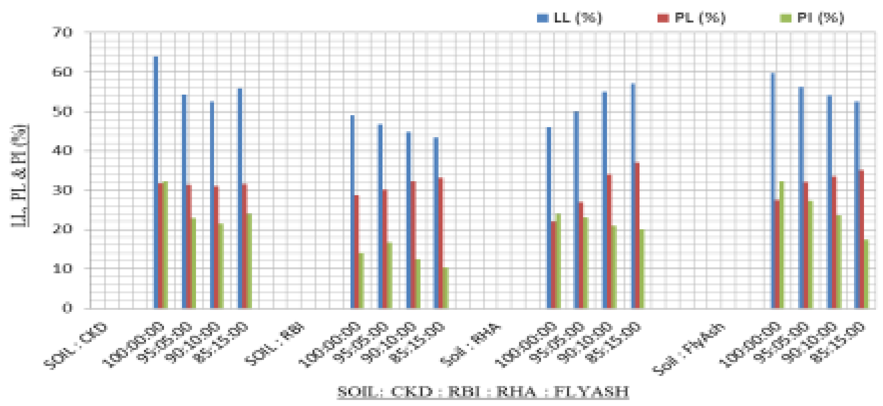

Fig. 1 Change of LL, PL and PI of soil with CKD, RBI Grade 81, RHA & Flyash

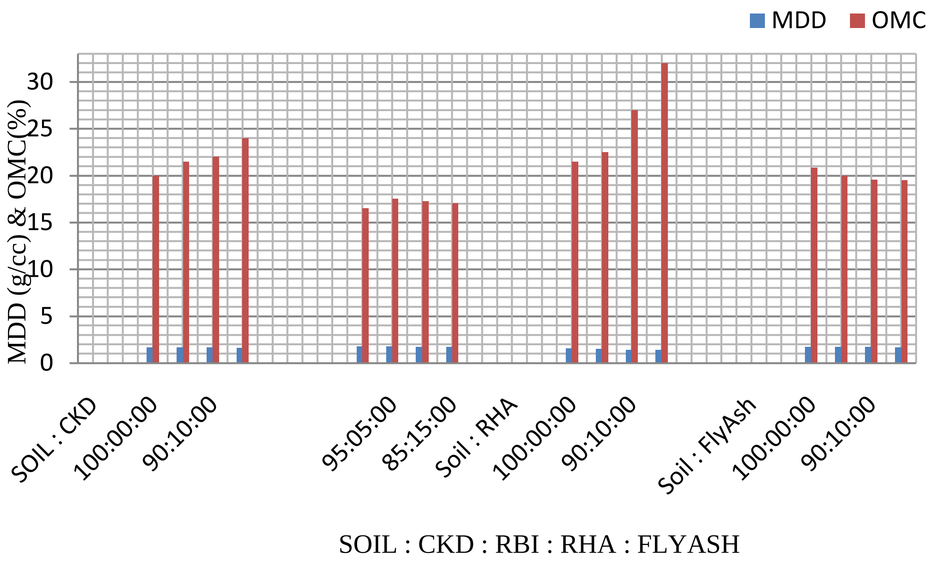

Fig. 2 Change of MDD & OMC of soil with CKD, RBI Grade 81, RHA & Flyash

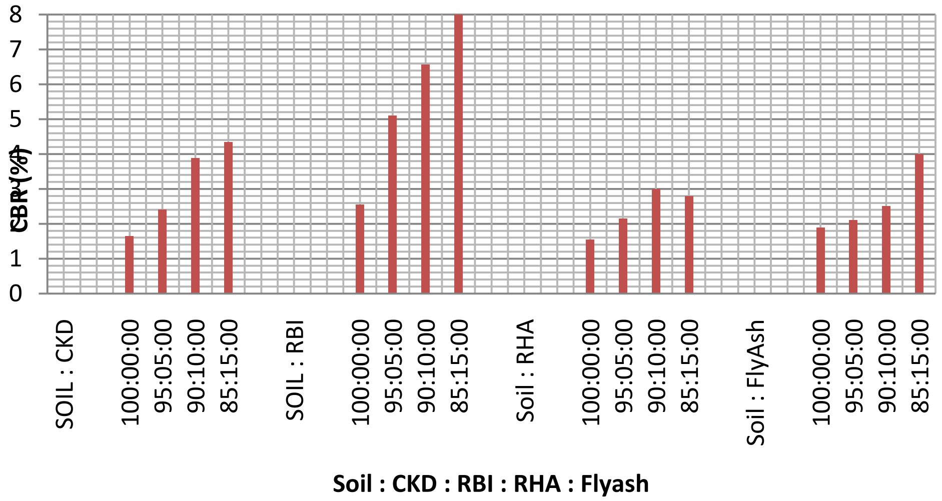

Fig. 3 Change of CBR values of soil with CKD, RBI Grade 81, RHA & Flyash

VI. CONCLUSION

Although the research that has been performed on clayey soil with different admixtures gives wide variety of results on several issues from which the following qualitative conclusions can be drawn. The liquid limit, plastic limit, plasticity index and the MDD value of soil decreases with increase in content of CKD. When CKD is added to the soil, it increases the CBR value (4.35 %) and UCS value from 88.3 kPa to 139.5 kPa for untreated and treated soil mixtures, respectively, at 28-day curing time. The stabilizer RBI-81 is effective in reducing the plasticity characteristics of the expansive soil. The CBR values of soil, increased from 2.55 % to 8.02 % with 15 % RBI grade 81. When Fly ash is added to the soil, it increases the CBR value (4 %) and UCS value from 455 kPa to 570 kPa for untreated and treated soil mixtures, respectively, at 28-day curing time. With the increase in Rice husk ash percentage the Optimum moisture content increases from 21.5%to 32%. From figure number 1, it can be concluded that the consistency values of stabilized soil with RBI grade 81 gives the satisfactory results compared with the soil used with other admixtures (CKD, RHA and Fly ash) OMC Value of RBI Stabilized soil increases up to 5 % but slightly decreases after that. However, the maximum dry density shows a slight variation with the increase in percentage content of RBI grade 81. From figure number 3, it can be concluded that CBR value gives the best results with soil and RBI grade 81.

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