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Effect of Cement Kiln Dust (CKD) and Fly Ash (FA) on the Unconfined Compressive Strength of Clayey Soil

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Abstract: As we know soil is a lowermost stratum onto which all the structural loads is to be transferred. In this research paper we have consider cohesive soil (clay) for our study as settlements in cohesive soil is time dependent. So its bearing capacity is totally dependent on its cohesion i.e. unconfined compressive strength. Through our research paper we are showing the effect on unconfined compressive strength when we are stabilizing the soil with cement kiln dust and fly ash.

Introduction

Soil consists of air, water and rock particles, generally produced by the crushing of rocks. Soil Properties can be speed up by accumulating chemicals and cementitious additives and this procedure of enhancing the engineering properties of soil is called soil stabilization. It is the process in which the soil accessible for building works is inadequate for designed purpose and made stabilize by adding various additives as Cement, Bituminous and chemical material etc. These added substances can be utilized with a mixture of soils to enhance the engineering properties. The efficiency of added substances relies on type of soil and the quantity of added substance utilized are considering presently. These chemical supplements vary from waste items to produced materials which include Portland cement, Fly ash powder, Chemicals and CKD.

Materials

Clay is a fine-grained natural rock material that consolidates one or more soil minerals with metal oxides and natural matter. Geological clay deposits are generally consists of phyllosilicate minerals having inconsistent quantity of water fascinated in the mineral composition. Clays are plastic because of their water content and turn out to be hard, weak and non-plastic after drying or terminating

TABLE NO- 1 PROPERTIES OF SOIL

S.NO	PROPERTIES of Soil	Value
1	LL	**37.5**
2	PL	**22.5**
3	PI	**15**
4	Classification of soil	**CI**
5	Specific Gravity	**2.63**
6	O.M.C	**16.5%**
7	M.D.D	**17.5kN/m^3**
8	U.C.S	**212.80kN/m^2**

CEMENT KILN DUST (CKD)

CKD is a dust comparable to cement powder. Cement kiln dust can be broadly characterized into four classes, based on the kiln operation and level of partition in the dust accumulation system. We have two sorts of furnace process: wet-process kiln, which needs the materials in a slurry form and dry-process kilns are that took the materials in a dry form. In both procedures, the dust can be gathered in two ways. Initially, divided portion of the dust can be isolated and return back to the furnace from the dust gathering system nearest to the kiln, or the large amount of dust produced can be reused. Bulk amounts of CKD are created with the production of cement clinker by the dry procedure.

TABLE NO- 2 CHEMICAL COMPOSITION OF CEMENT KILN DUST

S.NO	Constituents	Percentage (%)
1	$CaCo_3$	55.5
2	SiO_2	13.6
3	CaO	8.1
4	K_2SO_4	5.9
5	$CaSO_4$	5.2
6	Al_2O_3	4.5
8	KCI	1.4
9	MgO	1.3
10	Na_2SO_4	1.3
11	KF	0.4
12	Others	0.7

FLY ASH

Fly ash is a fine grained powder left as residue after the burning of coal during the production of electricity. It mainly consists of silica, alumina and iron. It is finely separated residue that outcomes from the ignition of pounded coal and is transported from the burning chamber by fume gases. One of the residues left in burning generally refers to ash created through burning of coal. Fly ash has slight cementitious value because in moisture it reacts chemically and cementitious compounds are formed which improves the strength and compressibility characteristics.

TABLE NO- 3 PROPERTIES OF FLYASH

S.NO	Constituents	Percentage(%)
1	SiO_2	57.48
2	Al_2O_3	30.68
3	Fe_2O_3	5.98
4	CaO	1.69
5	MgO	1.88
6	Na_2O	0.77
7	K_2O	1.21
8	P_2O_5	0.31

PROCTAR TEST- The test was performed on soil and cement kiln dust mix to find out the optimum amount of CKD. Various percentages of CKD gives the O.M.C and M.D.D as shown in table below-

TABLE NO- 4 OMC & MDD of CKD: Soil Mix

S.NO	PROPORTION	O.M.C(%)	M.D.D(kN/m^3)
1	Virgin Soil	16.5	17.5
2	CKD:S= 6:94	16	17.9
3	CKD:S= 12.88	15	18.1
4.	CKD:S= 18:82	14.5	18.95

Unconfined Compressive Strength

The UCS test was performed as per International Standard: 2720 Part X. In the starting sample for CKD and soil are prepared. 3Samples are made for every ratio. Samples are cured for 7 days. Main aim after this is to optimize CKD. Afterwards (CKD:FA:S) mix is prepared at OMC. Samples were then cured for 7, 14 and 28 days.

TABLE NO- 5 U.C.S VALUES FOR SOIL :CKD MIX

S.No	DESIGNATION	Curing period (days)	UCS(kN/m^2)
1	Virgin Soil	7	212.80

2	CKD:S=6:94	7	451.40
3	CKD:S=12:88	7	817.38
4	CKD:S=18:82	7	700.88

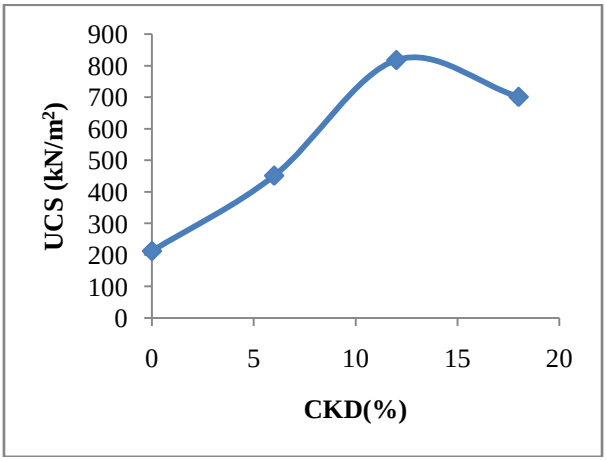

FIGURE NO -1 GRAPH SHOWING THE VARIATION OF U.C.S WITH CKD AFTER 7 DAY CURING

From the above values of U.C.S the maximum values were obtained at 12% CKD and then the proctor test were conducted on the various value of flyash and constant value of CKD.

TABLE NO-6 OMC & MDD of CKD:FLYASH: Soil Mix

S.NO	PROPORTION (CKD:F:S)	O.M.C (%)	M.D.D (kN/m^3)
1	12:5:83	17	17.8
2	12:10:78	19	17.2
3	12:15:73	20	16.95

TABLE NO -7 UCS of CKD:FA:S Mix for 7days

S.NO	**PROPORTION (CKD:S:F)**	**U.C.S (kN/m^2)**
1	12:83:5	830.91
2	12:78:10	850.27
3	12:73:15	840.35

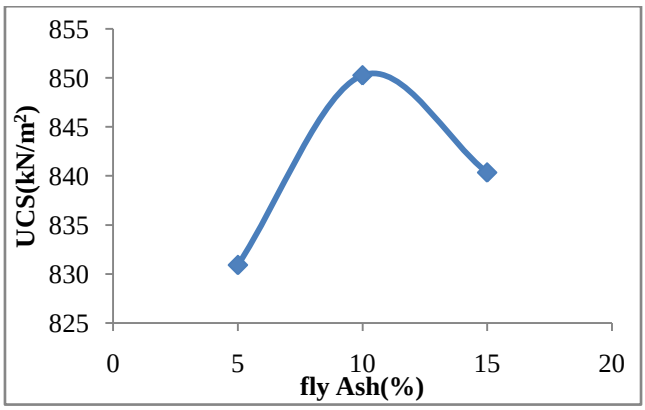

FIGURE NO -2 GRAPH SHOWING THE VARIATION OF U.C.S WITH FLYASH (12% CKD) AFTER 7 DAY CURING

Table 8 – UCS of CKD:FA:S Mix for 7days

S.NO	PROPORTION (CKD:S:F)	U.C.S (kN/m^2)
1	12:89:5	999.10
2	12:84:10	1246.3
3	12:79:15	956.83

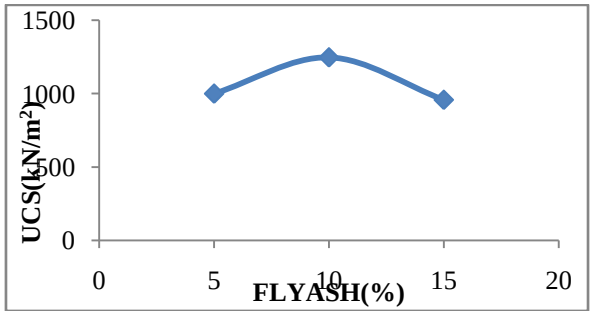

FIGURE NO -3 GRAPH SHOWING THE VARIATION OF U.C.S WITH FLYASH (12% CKD) AFTER 14 DAY CURING

TABLE 9 - UCS Value of CKD: FA:S Mix for 28 days

S.NO	PROPORTION (CKD:S:F)	U.C.S (kN/m^2)
1	12:83:5	1367.34
2	12:78:10	1501.88
3	12:73:15	1277.21

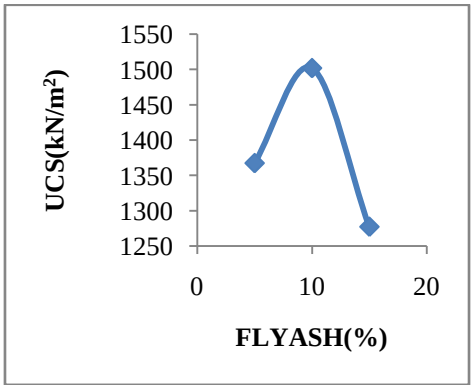

FIGURE NO -3 GRAPH SHOWING THE VARIATION OF U.C.S WITH FLYASH (12% CKD) AFTER 28 DAY CURING

Discussions

COMPACTION TEST

Maximum dry density: From the table and graph shown above, it is found that with the increment in percentage of CKD, MDD increases. The M.D.D of virgin soil is 17.5kN/m^3 with the increase in % of CKD from 6% to 18%, the deviation of 6%, MDD increase from 17.9 to 18.95. The trend indicates that the MDD go on increasing with increase in percentage of CKD. The increment in MDD is because of gradation of CKD and as the specific gravity of CKD is more than the soil, so M.D.D increases.

From the above table and graph, it gets clear that, as the percentage of fly ash increases, MDD decreases. The MDD of virgin soil is 17.5. With increment in amount of fly ash from 5-15% with variation of 5% the MDD decreases from 17.8 to 16.95kN/m^3. The MDD decreases because specific surface area of fly ash is more than that of soil specimen. Due to the chemical reaction the crystals are created. These are difficult to compact and

there is increase in void ratio. Gradation of fly ash and as the specific gravity of fly ash is less than the soil particles so the MDD decreases.

Optimum moisture content: From the above table and graph, it is clear that with the increase in amount of CKD, the OMC is decreasing. The OMC at 6%, 12% & 18% is 16, 15, 14.5 respectively. The OMC decreases as void spaces are plugged in with proper gradation and specific surface area of mix also decreases which requires less water.

From the table and graph above, with increase in percentage of fly ash, OMC increases. With increment in % of Fly ash from 5-15%, with the deviation of 5% the OMC increases from 17, 19 and 20. The OMC increases as we add fly ash. The void spaces are plugged out with the proper gradation and the specific surface of mix increases which needs more water.

UNCONFINED COMPRESSIVE STRENGTH TEST

UCS is most preferred method for calculating the strength. The UCS is performed on CKD and soil. Sample is cured for 7 days. From above data, we get that % of relative increase in strength was maximum b/w 6-12%. Hence 12% CKD was taken as ideal value. The increment of UCS is because of accumulation of CKD to soil is because of pozzolonic reactions between alumina and silica from clayey soil &CKD, results in cementitious products. For detail study 12% CKD is used. Then with the constant % of CKD, UCS has been conducted by various percentages of Fly Ash. The % of Fly ash was 5%, 10%& 15%. Specimens are cured for 7,14,& 28 days. From graphs, it is clear that strength of the sample increases with increase in curing period. The motive in the increase in strength with increase in curing period is because of various reactions related to the strength gain in the mix. Different reactions responsible for this is hydration, Pozzolonic reactions and carbonation

Conclusions

The Conclusions drawn from this study on the basis of results obtained are:

1. It has been noted that with the increment in amount of CKD, MDD increases and OMC decreases. The decrement in OMC with increase in CKD amount may be credited to the addition of material which is considered as silty to the parental material. The increase in MDD as cement kiln dust content increases may be because of gradation of CKD and as the specific gravity of CKD is more than the soil, so M.D.D increases.
2. It has been noted that with the increase in Fly ash content, OMC increases and MDD decreases, this is because the Fly ash is having the more specific surface area and thus it absorbs more water. The existence of ash having low specific gravity may be the reason for decrease in density.
3. From results, we come to know that optimized value of CKD was found to be 12%. This percentage of CKD was used for detailed study with Fly ash.
4. The study reveals that the action of CKD on soil is a successful technique of stabilization for problematic soils. Shortly, it is determine that utilizing this waste is a useful suggestion which is economical and atmosphere friendly, using this waste is a useful proposal which is economical and atmosphere friendly as well. Outcomes in this study have been used in designing foundations on compacted stabilize clay beds.

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