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REVIEW ON STABILIZATION OF CLAYEY SOIL USING CALCIUM CARBIDE RESIDUE AND FLY ASH

[1]Shabana Azimi , [2]Dr. D.K. Soni
[1]M.Tech. Student , [2]Professor

[1]Department of Civil Engineering, NIT Kurukshetra, Haryana-136119
[2]Department of Civil Engineering, NIT Kurukshetra, Haryana-136119

ABSTRACT : It has become a common problem that newly established engineering projects are located in areas with weak, soft and incompatible soils . This becomes extremely risky in geotechnical field because such soils are more liable to differential settlements, low compressive strength, and high compressibility. The accepted usual technique to mitigate such issues is the process of soil stabilization. Calcium carbide Residue (CCR) and Fly Ash (FA) are both waste products from acetylene gas factories and power plants, respectively. The mixture of CCR and FA produces a cementitious material because CCR contains a lot of $Ca(OH)_2$, while FA is a pozzolanic material. This review paper focus on the possibility of using this cementitious material (a mixture of CCR and FA) to improve the strength of clayey soil. Strength development is investigated using the Unconfined Compression Test. This study investigates the use of two kinds of industrial wastes Calcium Carbide Residue and Fly Ash in the stability of soil. These industrial wastes are generally dumped or thrown, which produce detrimental effect on the environment. The use of these wastes in soil stabilization improve the properties of soil which helps in various purposes such as designing of pavements, embankments, earth slopes, in filling of low lying areas, etc. and save the environment from the ill impact. The soil can be treated and stabilized well at a relatively low cost by using these additives. The tests conducted on clayey soil are Atterberg Limits(Liquid Limit Test and Plastic Limit Test), Specific Gravity test, Proctor Test, Unconfined Compressive Strength(UCS) Test and California Bearing Ratio Test. Varying doses of FA and CCR are added to the soil to improve its properties.

Keywords - Fly Ash; Calcium Carbide Residue; Pozzolanic Material; Additives; Unconfined Compressive Strength Test

1. INTRODUCTION

Soil stabilization means the improvement of the stability or bearing capacity of a poor soil by the use of compaction, proportioning and the addition of suitable stabilizers or admixtures. Soil stabilization includes chemical, mechanical, physio-chemical methods to make the soil stabilized. Basically excavation of soil is an ideal technique for improving of soil in shallow depth, as in pavements. Stabilization method may be categorized as two main types: (a) improvement of soil properties of existing soil without using any type of admixture; and (b) improve the properties with the admixtures.

The greatest challenge before the processing and manufacturing industries is the disposal of the harmful residual waste products. Waste products which are generally toxic, ignitable, corrosive or reactive pose serious health and environmental hazards. Thus disposal of industrial waste is a major issue of the present generation. This major issue requires an effective, economic and environment friendly method to combat the disposal of the residual industrial waste products. Hence it is a common and feasible way to utilize these wastes in construction of roads, highways and embankments, so that the pollution problems caused by the industrial wastes can be greatly reduced. Huge amount of soil is used in the construction of roads and highways but sufficient amount of soil of required quality is not available easily. These industrial wastes which are used with natural soil in the construction not only solve the problems of disposal and environmental pollution but also help to preserve the natural soil.

1.1 CHEMICAL STABILIZATION

In chemical stabilization, soil is stabilized by adding different chemicals. The chemicals fill up the pores in soil and finally dense hard mat type strata is formed. Chemicals are mixed up in soil either by mix-in-place or by plantmix method. The strength of the soil increases with the use of chemicals. Setting time and curing time can be controlled using chemical stabilization. The compacted density of the soil is increased. Chemical stabilization improves the permeability of soil. The disadvantage being the cost and the requirement of extra experienced labour.

2. ITERATURE REVIEW

- **Krishnan & Reddy (2016)** treated two different soil samples P & Q with 3%, 5%, 7%, 9% of CCR. They concluded that the swelling nature of soil decreases with increase in CCR content. The characteristic strength of samples

P& Q increases upto 5% and further it decreases. OMC & MDD of sample P is 18% and 1.67g/cc and sample Q is 23.6% and 1.507g/cc.

On addition of 5% CCR the OMC and MDD of sample P becomes 23.8% and 1.563g/cc and sample Q becomes 23.8% and 1.409g/cc. The UCS of sample P and Q are 0.168N/mm^2 and 0.145N/mm^2 respectively and on addition of 5% CCR, the value of sample P and Q increases to 1.268N/mm^2 and 1.268N/mm^2 respectively with 14 days curing period and later on decreases. The CBR value of sample P and Q are 3.973% and 4.04% respectively and on addition of 5% CCR with 14 days curing, the CBR of sample P and Q increases to 58.20% and 61.32% respectively.

- **Bandyopadhyay et al.(2016)** stated that on addition of CCR in soil, the OMC increases and MDD decreases because CCR acts as a drying agent. The value of UCS for virgin soil is 2.541kg/cm^2 and the maximum value of UCS is 3.042kg/cm^2 at 0.75% CCR by weight of soil, it means the strength of soil was maximum when the % of CCR added to the

soil is 0.75%. the value of CBR for virgin soil was 3.85% and increases to 4.18% at 0.75% CCR by weight of soil. The maximum UCS value obtained was 4.582kg/cm^2 for 25% of GGBS by weight of soil. The maximum value of CBR was obtained 6.74%, when percentage of GGBS was 25% by weight of soil. Hence from strength analysis, use of 25% GGBS and 0.75% CCR by weight of soil is advisable.

- **Isah and Sharmila (2015)** used CCR and CSA for stabilization of CI and CH soils. CCR was fixed at 4% and 6% for CI and CH respectively and then CSA was varied 4%, 9%, 14% and 19%. UCS test results with combination of (4% CCR + 4% CSA) for CI soil & (6% CCR +4% CSA) for CH soil with 7 days curing period improved soil strength up to 11.38 & 6.03 times than that of the virgin soil.

- **Sabat and Nayak (2015)** stated that MDD and OMC reach at 15.2kN/m^3 from 16.2kN/m^3 and 25.8% from 22% when the

percentage of FA-CCR is 30%. The UCS goes on increasing till the percentage of FA-CCR was 24%, further UCS value decreases as it goes higher and the UCS reaches a maximum value of 298kN/m^2. The optimum percentage of FA-CCR was 24% having FA=16% and CCR=8%.

- **Karthik et al. (2014)** performed CBR and UCS test in varying percentage such that 3, 5, 6 and 9%. The CBR value on virgin soil was 3.1 and increased to 55% with addition of 6% Fly Ash. The UCS value on virgin soil was 3.88N/cm^2 and increased to 128% with addition of 6% Fly Ash. The optimum CBR and UCS values of soil were found on 6% Fly Ash.

- **Singhai A.K. et al. (2014)** studied that liquid limit and plasticity index decreases to 54% and 85% respectively by adding Fly Ash content to 20% and RHA content to 25%.

- **Tripathi R.K. et al. (2013)** performed CBR by using Fly Ash and Granulated Blast Furnace Slag (GBS). The dose of GBS was taken as 3, 6, and 9% and Fly Ash used was in ratio 3, 6, 9 and 12% to stabilize soft soil. The CBR (soaked) value on virgin soil was 2.05% and increased to 8.28% with addition of 3% Fly Ash and 6% GBS. The CBR (unsoaked) value on virgin soil was 8.14% and increased to 18.2% with addition of 3% Fly Ash and 6% GBS. 3% Fly Ash and 6% GBS was determined as an optimum percentage for soft soil.

- **Ramlakhan et al. (2013)** performed CBR and compaction test and concluded that with increasing content of Fly Ash, the OMC of black cotton soil increases and MDD decreases. Also, CBR value increases upto 40% of Fly Ash and later on it decreases.

- **Horpibulsuk et al. (2012)** explained that in standard proctor test, maximum dry unit weight of soil and OMC are 16.9kN/m^3 and 18% respectively, the maximum dry unit weight of soil with 10% CCR and 20% CCR is 15.9kN/m^3 and

14.8kN/m^3 respectively. The MDD decreases with increase in OMC due to the lower specific gravity of CCR than that of clay.

- **Makaratat N., Jaturapitakkul C., and Laosamathikul T. (2010)** studied the effects of Calcium Carbide Residue–Fly Ash Binder on Mechanical Properties of Concrete. The effects of fly ash finenesses and water to binder (W/B) ratios of CCR-FA concretes on setting times, compressive strength, modulus of elasticity, and splitting tensile strength were investigated.

- **Y. J. Du , Y. Y. Zhang , and S. Y. Liu (2009)** investigated Strength and California Bearing Ratio Properties of Natural Soils Treated by Calcium Carbide Residue which is used as embankment filling material in China Highway Engineering practice . From the tests, it is found that calcium carbide residue treated soils have better performance than that of lime treated soils .

- **Consoli et al. (2001)** have reported the possibility of using CCR and fly ash to stabilize a nonplastic, silty sand. The study of soil stabilization with a mixture of CCR and pozzolanic materials is an engineering, economic, and environmental challenge for geotechnical engineers and researchers.

3. MATERIALS USED AND METHODOLOGY

3.1 MATERIALS-

3.1.1 FINE GRAINED SOIL

For the experiments locally available clayey soil was collected from nearby village of NIT Kurukshetra.

3.1.2 Calcium Carbide Residue (CCR) –

CCR is by-product of Acetylene gas Production Process which is a slurry that mainly contains Calcium Hydroxide ($Ca(OH)_2$) along with SiO_2, $CaCO_3$ and other metal oxides. In India, there are many Acetylene Gas factories and PVC Chemical Plants which produces CCR in large amount which is mainly dumped in the landfills causing environmental pollutions due to its alkalinity. CCR production is described in the following equation:

$$CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2$$

(Calcium Carbide) (Acetylene) (Calcium Hydroxide or CCR)

Due to its high base, the CCR was hardly utilized in any work and dumped into disposal area in slurry form. After being sun -dried for a few days, the slurry form is changed to dry form. The dissociation of $Ca(OH)_2$ leads to an increase in the ph values of the pore water. Strong bases dissolve the silica and alumina from the clay particles (a natural pozzolanic material), in a manner similar to the reaction between a weak acid and a strong base. The hydrous silica and alumina then gradually react with the calcium ions (pozzolanic reaction), which hardens with time.

3.1.3 Fly Ash-

Fly ash is the finely divided residue that results from the combustion of pulverized coal and is transported from the combust ion chamber by exhaust gases. The chimneys of thermal power plants are used to capture the fly ash. It consists of SiO_2 and Al_2O_3 and is pozzolanic in nature. In India its production is approximately 100 million ton per year and pollutes river water and p ut human beings life in dangerous situation by causing problems like lung damage. pH value is around 10 – 12. It is of two types and is classified as Class F fly ash which is produced by older and harder coal and it is cementing agent and pozzolanic containing less than 10% lime(CaO). The other one is Class C fly ash which is produced by younger lignite coal and contains more than 20% lime. Typical engineering applications include: portland cement concrete (PCC), soil and road base stabilization, flowable fills, grouts, structural fill and asphalt filler. The unique spherical shape and particle size distribution of fly ash make it a good mineral filler. Fly ash utilization, has significant environmental benefit including: reduction in amount of coal combustion products that must be disposed in landfills, and conservation of other natural resources and materials.

3.2 PROBLEM STATEMENT

Lot of work have been carried out for improvement of soil properties using different stabilizers like cement, lime, chemicals, etc. Sometimes single material was used and sometimes combination of two or more materials were used to enhance strength of soil. Many investigations have been carried out but still there is a need for research to use waste product locally available which is also hard to dispose off. CCR is such a waste product which is byproduct of acetylene gas production factories. Since it has calcium in sufficient quantity therefore can be used in stabilizing clayey soil. Similarly a pozzolanic material fly ash may be used in combination of CCR.

In this study fly ash and calcium carbide residue are used to improve the Unconfined Compressive Strength and Compaction characteristics of the soil.

3.3 OBJECTIVES OF RESEARCH

The objectives of the present study are:-

- To determine the effect of Calcium Carbide Residue and Fly ash on Maximum Dry Density(MDD) and Optimum Moisture Content(OMC) of clayey soil.

- To determine the effect of CCR and Fly Ash on the Unconfined Compressive Strength(UCS) of clayey soil.
- To determine the effect of CCR and Fly Ash on the CBR Value of clayey soil.

3.4 METHODOLOGY

Following tests will be performed to meet the objectives of the study:-

1. Soil Index Properties
   i. Liquid Limit Test
   ii. Plastic Limit Test
   iii. Specific Gravity Test
2. Maximum Dry Density (MDD) and the corresponding Optimum Moisture Content (OMC) of the soil by Proctor Test.
3. Unconfined Compressive Strength Test (UCS)
4. California Bearing Ratio Test (CBR)

Table 1: VARIABLES OF STUDY

S.No.	Set Type	Fly Ash(%)	CCR(%)
1.	Virgin Soil	0	0
2.	^{S}FA	10	0
3.	^{S}FA	15	0
4.	^{S}FA	20	0
5.	^{S}FA	25	0
6.	^{S}FA+CCR	X	1
7.	^{S}FA+CCR	X	3
8.	^{S}FA+CCR	X	5
9.	^{S}FA+CCR	X	7
10.	^{S}FA+CCR	X	9

Where X is optimized value of Fly Ash.

4. CONCLUSIONS

- The soil taken from different site present in the same locality have different properties in general.
- The waste product i.e. Calcium Carbide Residue and Fly Ash can be used to increase the stability of soil.
- The optimum amount of CCR and FA in the soil will increase stability of soil at maximum extent.
- Considerable increase in compressive strength and cohesion of soil with the addition of optimum amount of CCR and Fly Ash
- The amount of mixture of CCR and Fly ash added to the soil cannot be generalised but standard increment is observed till mixing 15-20 % of soil weight as further adding increase the strength in very small quantity which is not profitable at all.
- Considerable increase in CBR Value of the clayey soil with the addition of optimum amount of CCR and Fly Ash.
- From all the work we had done so far we can conclude that waste materials Calcium Carbide Residue and Fly Ash mixture can be used to increase the strength of the soil which also decrease the environmental pollution cause by these two.

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