Effect of Lime and Fly Ash on Electro Kinematic Properties of Soil

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Abstract- The present work aims to find the effect of additives namely Lime and Fly ash on Cation Exchange Capacity (CEC), Compaction characteristics, and Unconfined Compressive Strength (UCS) of two soils. The two soils used in this study are Sandy Clay (SC) and Low Plasticity Clay (CL). First the soils were mixed individually with varying contents of lime and fly ash to find out their effects on Cation Exchange Capacity (CEC) and for conducting Light compaction test to find the compaction characteristics. Then the treated soil samples compacted at Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) were tested for Unconfined Compressive Strength (UCS) at different Curing periods. From the experimental results obtained, it is observed that for both soils, Cation Exchange Capacity (CEC) decreases more with increase in fly ash content than with Lime content. Also Optimum Moisture Content (OMC) increases and Maximum Dry density (MDD) decreases with increase in Lime and Fly ash content for both the soil samples. The Unconfined Compressive Strength (UCS) increases with lime and fly ash content up to a certain limit beyond which further increase in lime and fly ash content does not increase the Unconfined Compressive Strength (UCS). The Unconfined Compressive Strength (UCS) increases more with increase in Lime content than by increase in fly ash content. The Unconfined Compressive Strength (UCS) increases with curing time.
Keywords: - CEC, UCS, MDD, OMC, LIME & FLY ASH, SC, CL

I. INTRODUCTION

In India, there is an increase in the number and capacity of the thermal power plants because of the increase in demand for electricity. Most of these thermal power plants use coals which are of inferior quality. These inferior quality coals produce huge amount of fly ash. According to the Central Electricity Authority (CEA) report on fly ash generation and utilization, 61 percent and 57.63 percent of the fly ash produced was utilized during the year 2012-2013 and 2013-2014 respectively. Thus, the utilization of fly ash in India varies between 50-60% and rests are disposed in ash ponds. This disposed fly ash and even the fly ash which is utilized for reclamation of low-lying areas has the tendency of leaching the heavy metal pollutants and thus polluting the groundwater. This ground water pollution can be controlled by increasing the Cation Exchange Capacity (*CEC*) of sub soil through application of additives such as lime, fly ash, cement etc. so that the individual soil colloids can hold the pollutant cations at their exchange sites.

So, if any of the additives which doesn't affects or increases the Cation Exchange Capacity (*CEC*) of the soil along with increasing the strength of the soil then the additive would be beneficial in case of geo-environmental projects.

II. PREVIOUS WORK

Zhang and Xing (2021) studied the stabilization of expansive soil by lime and fly ash. The Optimum Moisture Content increased and the Maximum Dry Density decreased with increase in percentage of lime.

Kumar et al. (2021) studied the effect of fly ash, lime, and polyester fibers on compaction and strength properties of expansive soil. With the increase in Lime content there is an increase in optimum Moisture content and decrease in maximum dry density. The Curing time did not increase the strength up to 4% of lime content. With the increase in the percentage of lime, strength increases and attains a certain maximum value and after that it starts decreasing.

Sakr et al. (2019) studied the geotechnical properties of soft clay organic soil stabilized with varying lime percentages of 1, 3, 5 and 7 percent. The unconfined compressive strength of 7 percentage lime increased nearly seven times for 60 day curing period.

Amu et al. (2018) tested the lime stabilization requirement and suitability of lime for three lateritic soil samples. These 3 soil samples were mixed with 2, 4, 6, 8, and 10 percent of lime and tested for compaction, CBR test, unconfined compression and undrained triaxial test. The CBR value, unconfined compressive strength and shear strength of the composite soil samples was improved to maximum value at 8 percent, 6 percent and 6 percent for the 3 soil samples.

Davoudi and Kabir (2017) tested a low plasticity soil for interaction with lime and sodium chloride. They concluded that unconfined compressive strength of soil increases with increase in lime content and curing time. However, after comparing the rate of increase in unconfined compressive strength, they concluded the optimum lime content as 6 percent.

Siddique and Hossain (2016) studied the influence of lime stabilization on engineering properties of expansive soil. The soil was stabilised with lime contents of 3%, 6%, 9%, 12% and 15%. The Optimum moisture content increased and maximum dry density decreased with increase in lime content. Unconfined compressive strength of the sample increased with increase in lime content. There was large increase in unconfined compressive strength with increase in curing period of upto 16 weeks.

Dash and Hussain (2015) studied the influence of lime on a silica rich non expansive soil and expansive soil. They concluded that beyond certain limits, the addition of lime reduces the improvement in strength predominantly in silica rich soil because of the formation of excess silica gel which is a highly porous structure.

Kaur and Singh (2014) found that the Optimum Moisture Content increased and the Maximum Dry Density decreased with the addition of lime. The soil gains compressive strength on addition of lime, but it continues only upto a certain percentage of lime and then it starts decreasing with the increase in lime content.

Muhmed and Wanatowski (2013) obtained the initial consumption of lime by the pH test given by Eades and Grim as 5 percent. The unconfined compressive strength was conducted on the composite soil sample at Optimum Moisture Content (*OMC*), wet side of *OMC* and dry side of *OMC*. They found that the maximum unconfined compressive strength developed at the Optimum Moisture Content (*OMC*).

Bairwa et al. (2012) studied the effect of lime and fly ash on geotechnical properties of Black cotton soil. At first, the Optimum Moisture content decreased and the Maximum Dry Density increased with the addition of 3% lime. Then a further increase in lime content resulted n increase of the Optimum Moisture content and the decrease of Maximum Dry Density.

Nalbantoglu (2011) observed the effect of fly ash for stabilizing expansive soil. He studied the effect of Fly ash on plasticity characteristics, swelling and Cation Exchange Capacity (*CEC*) of two soils. The Cation Exchange Capacity (*CEC*) of both the soils decreased with increase in fly ash content.

Akbulut and Arasan (2010) studied the variation of Electro-kinetic properties such as Cation Exchange Capacity (*CEC*), pH and Zeta potential in expansive soils treated with additives such as lime, cement, fly ash, and silica fume. With increase in fly ash content, the Cation Exchange Capacity (*CEC*) values decreased.

Zhang and Xing (2009) studied the stabilization of expansive soil by lime and fly ash. The increase in fly ash content leads to decrease in Maximum Dry Density and increase in Optimum Moisture Content.

Kolias et al. (2005) stabilised three soils predominantly clayey with fly ash and cement. The soil was tested with 5, 10 and 20 percent fly ash. The maximum dry density decreased and Optimum moisture content increased with increase in fly ash. For all the soils, with increase in fly ash content the Unconfined Compressive Strength increased.

Sezer et al. (2004) studied the utilization of a fly ash for improvement in clay properties. They observed the effect of fly ash on compaction characteristics, unconfined compressive strength and shear strength parameters of soil. The maximum dry density decreased and the optimum moisture content increased with increase in fly ash content. The unconfined compressive strength of the soil increased with the addition of fly ash.

III. PROBLEM IDENIFICATION

- The utilization of fly ash in India varies between 50-60% and the rest are disposed in ash ponds.

- The discharge of effluents from waste water treatment plants may lead to pollution of the ground water.
- The Optimum Moisture Content increased and the Maximum Dry Density decreased with increase in percentage of lime.

IV. RESEARCH OBJECTIVE

- To obtain the optimum lime content for maximum Unconfined Compressive Strength (*UCS*) of treated soil sample with varying lime content for a certain curing period.
- To obtain the optimum fly ash content for maximum Unconfined Compressive Strength (*UCS*) of treated soil sample with varying fly ash content for a certain curing period.
- To find out the changes in CEC, OMC and MDD due increase the content of fly ash & lime content.

V. METHOD

The laboratory testing program consists of geotechnical tests such as Atterberg limit test, grain size analysis, specific gravity test, compaction test, unconfined compressive strength and direct shear test. The other test to be performed is Cation Exchange Capacity (*CEC*) test and pH test.
The specific gravity of both the soil sample and fly ash was determined as per IS: 2720-Part 3 (1980) and the results are presented in Table 1.

Table 1: Specific Gravity of Soils and Fly Ash

SAMPLE	VALUES
Sesa Sterlite soil sample (Sandy Clay)	2.62
NTPC Darlipalli soil sample (Low Plastic Clay)	2.60
Fly ash	2.30

VI. RESULTS AND ANALYSIS

The Cation Exchange Capacity (*CEC*) values decreased with the increase in lime content for both the soil samples as can be seen in Figure 1. The decrease in Cation Exchange Capacity (*CEC*) obtained are similar to that obtained.

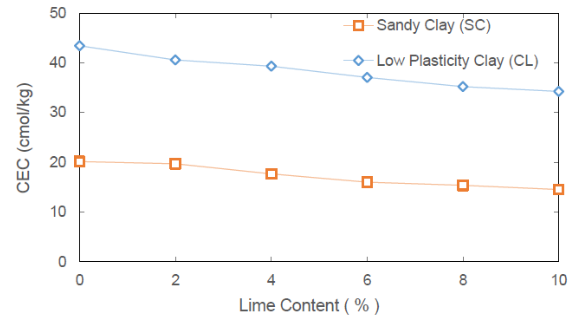

Figure 1: Variation in Cation Exchange Capacity (*CEC*) With Lime Content

The decrease in *CEC* values can be explained by the mineralogical changes occurring in the treated soils. The decrease in *CEC* can also be explained due to the formation of coarser particles with lime treatment which reduces the specific surface area.

As can be seen from Figure 2, with the increase of fly ash content in soil, the Cation Exchange Capacity (*CEC*) values decreased for both sandy clay (*SC*) and Low Plasticity clay (*CL*). It was observed that increase in fly ash content decreases Cation Exchange Capacity (*CEC*) values more rapidly when compared with increase in lime content. Similarly Akbulut and Arasan (2010) reported that fly ash is more effective in decreasing the Cation Exchange Capacity (*CEC*) values. decrease in Cation Exchange Capacity (*CEC*) values with increase in fly ash content.

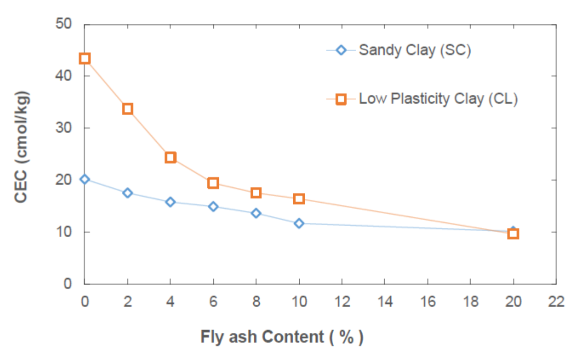

Figure 2: Variation in Cation Exchange Capacity (*CEC*) With Fly Ash Content

The rapid decrease in *CEC* values with addition of fly ash content as compared to addition of lime content may be because of the higher value of pH of lime. The higher pH of lime somewhat compensates the decrease in *CEC* as with increase in pH the *CEC* value increases.

The addition of lime in sandy clay and low plasticity clay results in decrease in maximum dry density and increase in optimum moisture content as can be seen from the compaction curve shown in Figures 3 and 4. Most of the researchers reported that with increase in lime content the maximum dry density decreases and optimum moisture content increases.

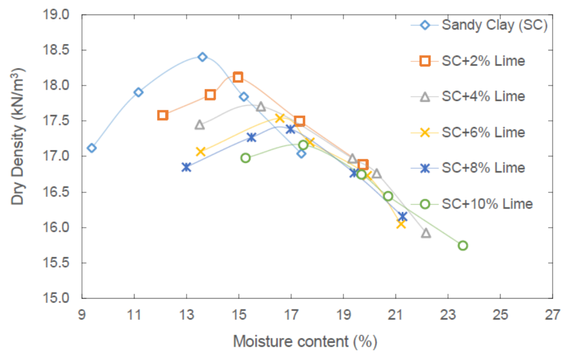

Figure 3: Light Compaction Curve for Sandy Clay (*Sc*) With Varying Percentage of Lime

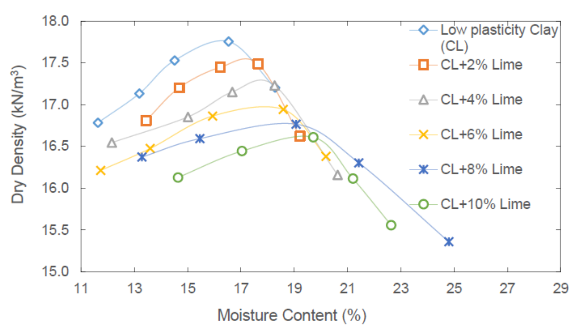

Figure 4: Light Compaction Curve for Low Plasticity Clay (*Cl*) With Varying Percentage of Lime.

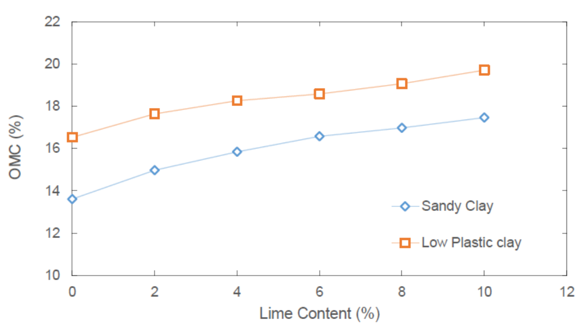

Figure 5: Variation of *OMC* With Lime Content

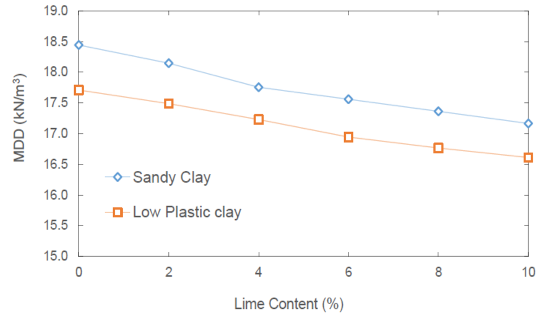

Figure 6: Variation of *MDD* With Lime Content

VII. CONCLUSIONS

An extensive Experimental program was undertaken to achieve the objectives of the present study. Two types of soils were mixed with varying quantities of lime and fly ash. The effect of these additives has been studied on Cation Exchange Capacity (*CEC*), Compaction characteristics and Unconfined Compressive Strength (*UCS*) of both the soil samples.

- The Cation Exchange Capacity (*CEC*) values decreased more with increase in fly ash content than with increase in lime content.
- The optimum moisture content (*OMC*) increases and maximum dry density (*MDD*) decreases with increased lime content and fly ash content for both sandy clay and low plasticity clay.
- The Optimum Lime Content (*OLC*) for Sandy Clay (*SC*) and low plasticity clay (*CL*) is 6 % and 8 % respectively based on Unconfined Compressive Strength (*UCS*) test.
- Similarly, the optimum fly ash content for Sandy Clay (*SC*) and low plasticity clay (*CL*) is 20 % and 25 % respectively.
- The Unconfined Compressive strength increases with increase in curing period for both soils treated with lime and fly ash.

VIII. SCOPE OF FUTURE WORK

- Effect of other additives such as cement, silica fume etc. on Cation Exchange Capacity (*CEC*) and unconfined compressive strength of soils.
- Effect of additives on Cation Exchange Capacity (*CEC*), Specific Surface Area (*SSA*) and Permeability and their interrelationship.

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