International Journal of Modern Trends in Engineering and Research
www.ijmter.com
e-ISSN No.:2349-9745, Date: 2-4 July, 2015

Effect of Compaction Delay on the Properties of Black cotton Soil Treated with Fly ash & Lime

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Abstract—Stabilization of soil is important to enhance the engineering properties of expansive soil like strength, volume stability and durability. During such process some unavoidable delays occurs between mixing the stabilizers with the soil and compaction of the stabilizers mix, which affects the properties of stabilized expansive soil. The effect of compaction delay on the properties of black cotton soil mixed with fly ash and lime has been investigated. Compaction tests (Modified proctor) and Unconfined Compressive Strength Tests were conducted on the soil-fly ash-lime mix (10%, 20%, 50% fly ash and 0%, 3%, 5% lime) with time delays (time delay between mixing the contents with water and compaction) 0, 12, 24, 48hrs. The prepared samples were tested to find out the effect of delayed compaction on dry density and unconfined compressive strength. The results obtained indicated that compaction and strength characteristics decrease with increases in fly ash-lime content as well as increases in compaction delay.

Keywords- Black cotton soil, Fly ash, Lime, Compaction delay, Maximum Dry Density, Unconfined Compressive Strength

I. INTRODUCTION

Black cotton soils are widely available in the north-western part of Maharashtra. These soils can be used as a construction material when it posses engineering properties such as high strength, low settlement and high durability. Difficulty is often experienced while working with such soils particularly in its field compaction. Black cotton soil experiences volumetric changes due to changes in water content and suction. However swelling occurs during rainy seasons and shrinkage occurs on evaporation of water during summer seasons. This peculiar problem of swelling and shrinkage causes damage to many engineering applications. In order to deal with such soil problem, stabilization of soil is needed. Soil stabilization is a technique aimed at increasing or maintaining the stability of soil mass and chemical alteration of soils to enhance their engineering properties.

However in developing country like India, due to industrial development there is increase in a demand for energy which has resulted in construction of considerable thermal power plants. At the moment there are total 87 working thermal power plants in India. This development has resulted in production of by-product like fly ash in large quantity. The disposal of fly ash requires large holding ponds, lagoons, landfills etc. Utilization of such hazardous by-product is very important to prevent the environment from its effect. Though fly ash has little cementatious value but in the presence of moisture it reacts chemically and forms cementatious compounds and attributes to the improvement to the strength and compressibility characteristics of soils. It has a long history of use as an engineering material and has been successfully employed in geotechnical engineering. Studies have been conducted in the past by many investigators regarding the use of fly ash alone or in addition with lime or cement for improving the properties of soils. But some unavoidable reasons like sudden rainfall, poor transportation; mechanical failure causes delay between mixing the stabilizers with the soil and compaction of the soil-stabilizers mix, which leads to changes in both compaction and strength characteristics of the soil. Hence it is important to study the effect of compaction delay between mixing and compaction on the engineering properties of black cotton soil stabilized with fly ash-lime.

II. MATERIALS USED

2.1 Characteristics of the Experimental Soil

Locally available soil was used for the experimental investigation. Natural black cotton soil was obtained from Nasik district in Maharashtra state. The soil was excavated from a depth of 1.5 m from the natural ground level. The soil is dark grey to black in color. The obtained soil was air dried, pulverized manually and passing through 425 micron IS sieve was used. Different experiments were conducted to characterize the soil.

Table 1. Properties of experimental black cotton soil

Sr. No.	Parameter	Values
1.	Specific gravity(Gs)	2.60
2.	Liquid limit(LL)	65%
3.	Plastic limit(PL)	43.58%
4.	Shrinkage limit(Ws)	12.35%
5.	Plasticity index(Ip)	21
6.	MDD	1.627 gm/cc
7.	OMC	19.20 %
8.	Swelling index	37%
9.	C.B.R (unsoaked)	22.95%

2.2 Chemical Properties of experimentalfly ash

Fly ash for the current investigation was collected from the coal based thermal power plant situated in Eklahare, Nashik district. It was collected in a dry form and transported in airtight polythene bags. The chemical properties of the fly ash are shown in table 2.

Table 2. Physical & chemical properties of experimental fly ash

Sr. No.	Parameter	% by mass
1.	SiO_2	58.66%
2.	MgO	1.82%
3.	SO_3	0.76%
4.	Na_2O	0.62%
5.	SiO_2+AL_2O_3+Fe_2O_3	92.56%
6.	Total chloride	0.027%
7.	Loss on ignition	1.94%
8.	Moisture content	0.25%
9.	Specific gravity	2.23

2.3 Chemical composition of hydrated lime

The hydrated lime used as stabilizing agent was procured in 25 kg bag from a reputable chemical store and stored in a cool and dry place away from whether effects.

Table 3. Oxide composition of hydrated lime

Sr no.	Oxide	Concentration(% by weight)
1.	CaO	67.16
2.	SiO_2	1.58
3.	P_2O_5	1.1
4.	Fe_2O_3	0.64
5.	AL_2O_3	0.50
6.	MNO_2	0.05
7.	Loss on ignition	26.87

III. EXPERIMENTAL PROCEDURE

The black cotton soil passing through 4.75 mm IS sieve was mixed in dry state with different percentage of fly ash-lime on weight basis. The required amount of water was added to the soil–fly ash-lime mix to carryout modified proctor compaction test. Immediately after addition of water, the compaction was carried out without any delay to get compaction characteristics of the soil-fly ash-lime mix for the given percentages of the admixtures. After getting the compaction curve, maximum dry density and corresponding optimum moisture content was obtained for the given soil-fly ash-lime mix. The predetermined amount of water was added to the mix to achieve the water content of the mix equal to the optimum moisture content for the mix. Then this wet mix was left undisturbed for a period of 0hr. (no delay), 12hrs, 24hrs, and 48hrs. During this period of time delay, care was taken to avoid the evaporation loss of water. After the required period of time delay the specimens were tested for MDD (Maximum Dry Density) and UCS (Unconfined Compressive Strength) by applying modified proctor test.

IV. EXPERIMENTAL PROGRAMME

Table 4 gives the details of testing programme and different mixtures of soil and fly ash used in the present investigation. In the mix designation, the fly ash content is indicated by numerals. Thus 20 FA indicates that 20% by weight is fly ash and the remaining is soil and BCS stands for black cotton soil.

Table 4. Testing programme

Designation of mix	Soil-fly ash mixture	% of Lime used	Delay in compaction
BCS	Black cotton soil only	Nil	Immediate,12hrs,24hrs,48hrs
20FA	80% soil + 20% fly ash	0,3,5	Immediate,12hrs,24hrs,48hrs
30FA	70% soil + 30% fly ash	0,3,5	Immediate,12hrs,24hrs,48hrs
50FA	50% soil + 50% fly ash	0,3,5	Immediate,12hrs,24hrs,48hrs

V. RESULTS AND DISCUSSIONS

Figure 1 shows the effect on Maximum Dry Density due to addition of different percentage of fly ash at no compaction delay. From the figure it can be observed that maximum dry density of modified compactive effort decreases with increases in percentage of fly ash. The addition of 0%, 20%, 30% and 50% of fly ash decreases the density from 1.627gm/cc to 1.58gm/cc, 1.556gm/cc and1.543gm/cc respectively. The decrease in density is mainly due to lower specific gravity of fly ash as compared to black cotton soil and immediate formation of cemented products reduces the density.

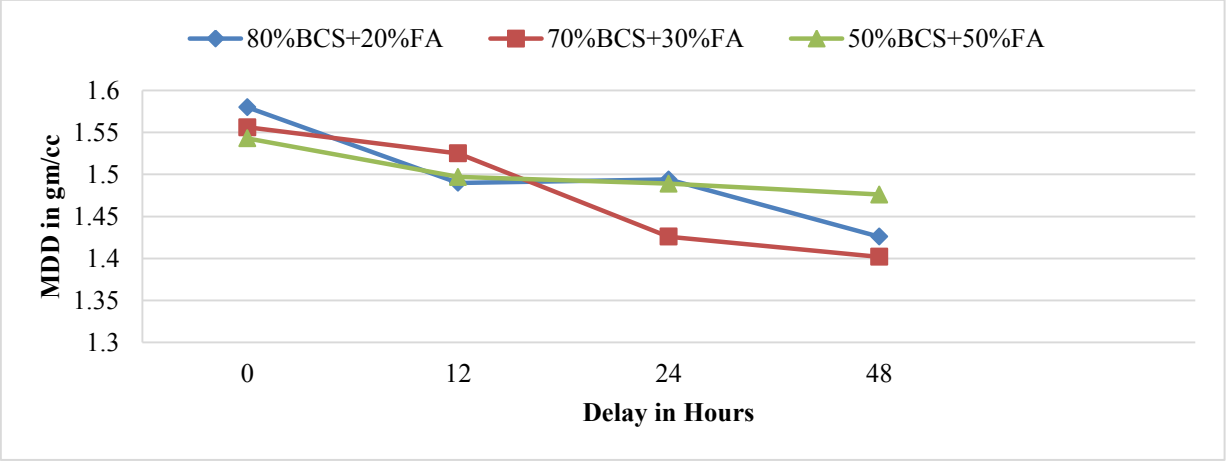

Figure 1. Variation of MDD due to delay in compaction of fly ash treated soil without lime

Figure 2 shows the changes to the MDD due to delay in compaction of black cotton soil mixed with fly ash and 3% lime. It can be observed that MDD further decreases with addition of 3% lime at no delay. For 80% addition of fly ash there is no major difference in dry density between without delay and to the 12 hrs delay, but after 12 hrs of delay it starts decreasing rapidly. However with addition of 50% fly ash, the rate of decreases of MDD slows down. Reduction in dry density of soil due to addition of lime is mainly because reduction in plasticity index of the soil. The maximum dry density drops and optimum water content increases so that the soil moves into a humidity range that can be easily compacted.

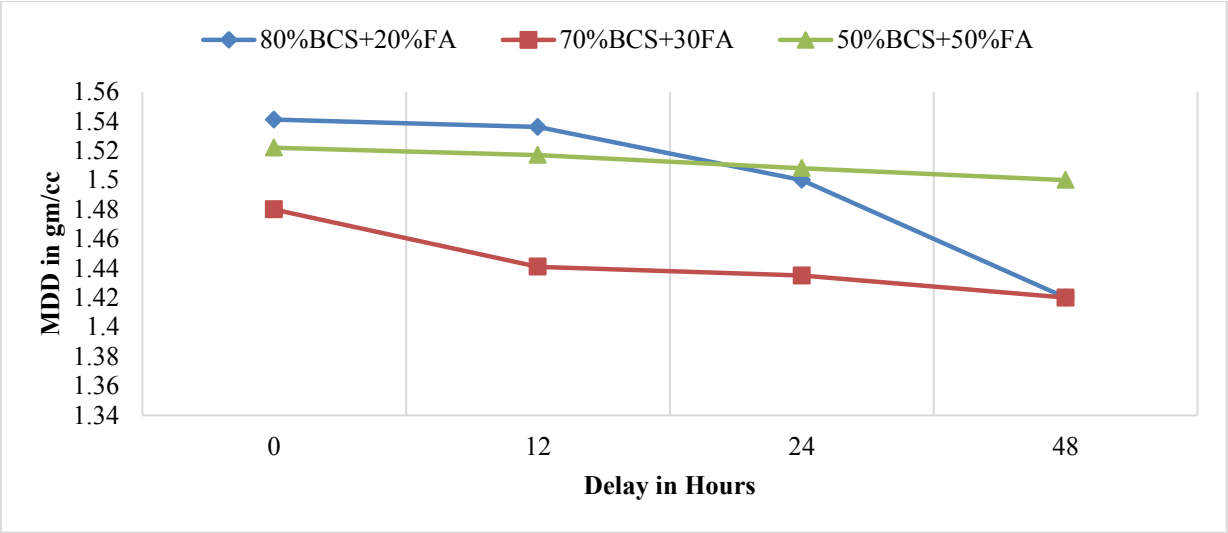

Figure 2. Variation of MDD due to delay in compaction of fly ash treated soil with 3% lime

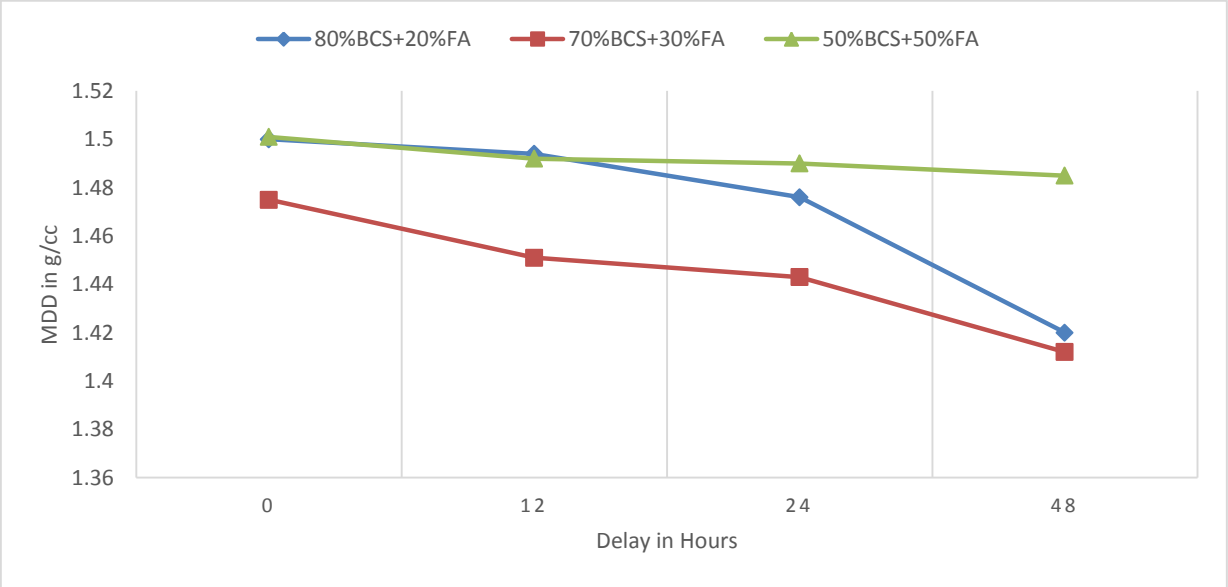

Figure 3. Variation of MDD due to delay in compaction of fly ash treated soil with 5% lime

Figure 3 shows the variation of MDD due to delay in compaction of fly ash treated soil with 5% lime. With further increase in lime content 80% addition of fly ash and 50% addition of fly ash attains almost same strength at no compaction delay and to the 12hrs delay, with further delay it starts decreasing for 20% addition of fly ash and there is not much effect on 50% addition of fly ash. Also dispersed structure of the soil is modified toflocculated structure due to the soil-lime reaction, which in turn offers more resistance against compactive energy.

Figure 4 shows the variation of UCS due to delay in compaction of fly ash treated soil without addition of lime. Figure 4 shows that increase in % of fly ash compressive strength decreases at no compaction delay. After 24 hours of delay 20% addition of fly ash soil mix and 30% addition of fly ash soil mix attains almost equal strength. However decrease in strength for 30% addition of fly ash is slow.

Figure 5 shows the variation of UCS due to delay in compaction of fly ash treated soil with addition of 3% lime. Addition of 3% lime increases the strength of all soil-fly ash lime mixes at no compaction delay as compared to all soil-fly ash mixes at no compaction delay. The increase in strength is more due to increase in cohesive intercept than an increase in frictional component. But as the percentage of fly ash increases strength goes on decreasing at no compaction delay. In case of 50%soil-50%fly ash-3%lime, the strength is not much affected by time delay.

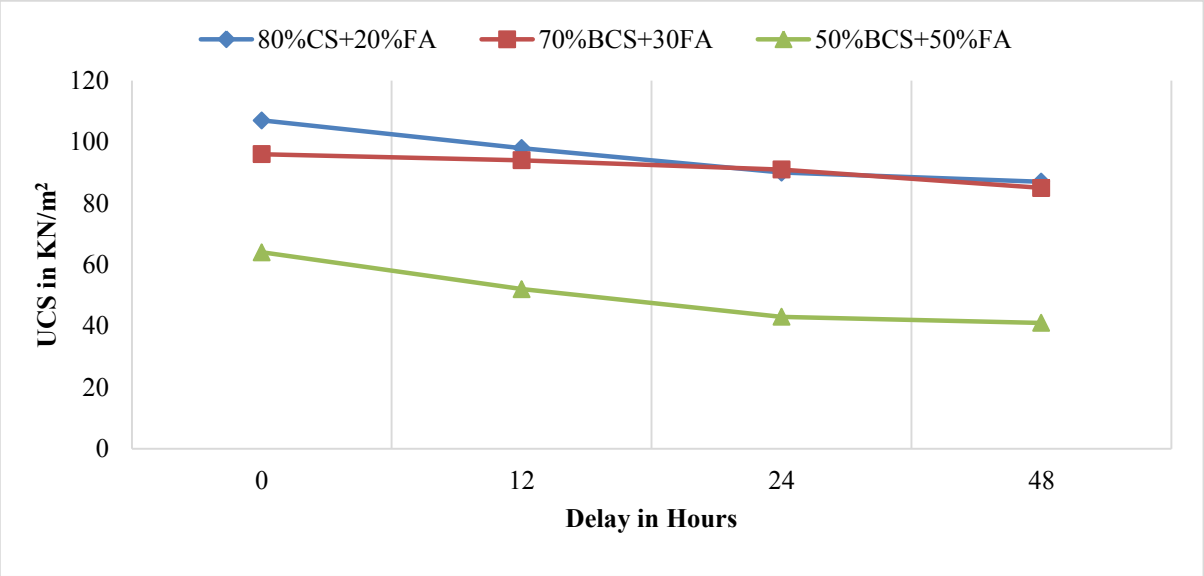

Figure 4. Variation of UCS due to delay in compaction of fly ash treated soil without lime

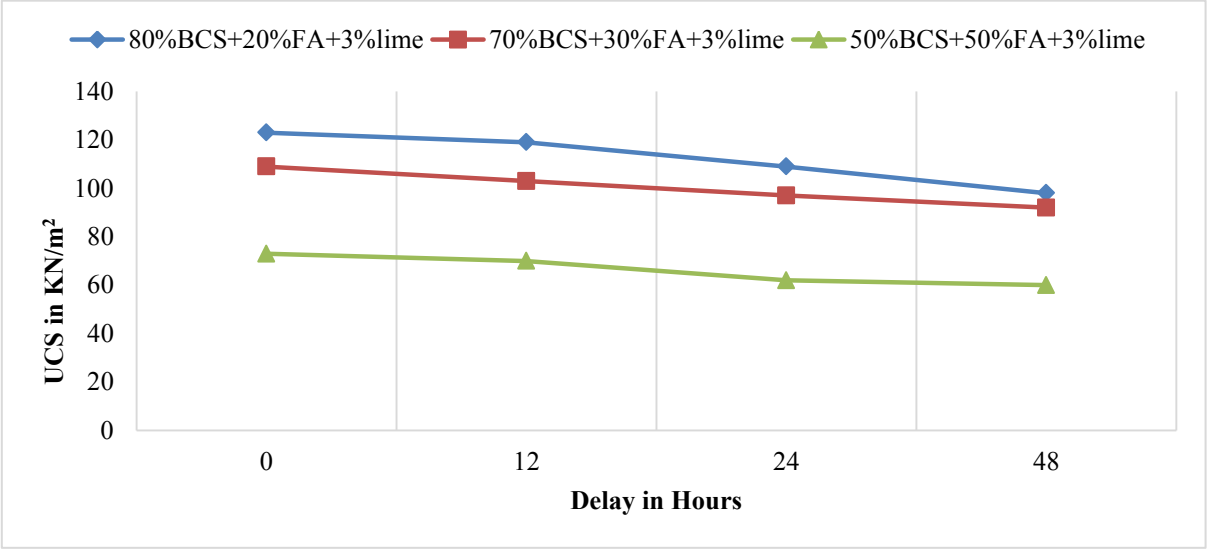

Figure 5. Variation of UCS due to delay in compaction of fly ash treated soil with 3% lime

Figure 6 shows variation of UCS due to delay in compaction of fly ash treated soil with 5% lime. With increase in lime by 2% strength further increases for soil-fly ash-5%lime mixes as compared to soil-fly ash-3%lime mixes at no compaction delay. Strength increases only up to optimum lime content which basically depends on the reactive silica of soil. After 24 hrs delay, 80%soil-20%fly ash-5%lime mix has attained the strength almost equal to strength of un delayed strength. Also in case of 50%soil-50%fly ash-5%lime mixes delayed compactive effects is almost negligible after 12 hrs of delay.

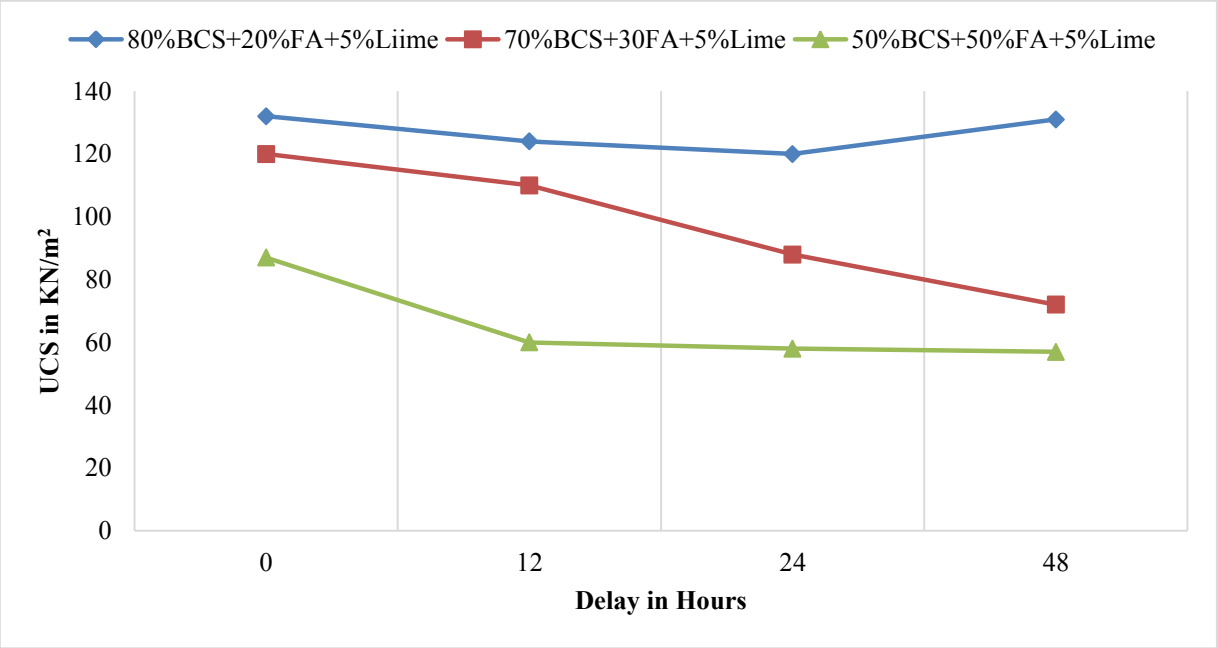

Figure 6. Variation of UCS due to delay in compaction of fly ash treated soil with 5% lime

VI. CONCLUSIONS

The following conclusions were drawn after this work has been carried out:

1. The maximum dry density decreases with increase in fly ash content and lime content as well as increase in compaction delay
2. Optimum water content increases with increase in fly ash content and lime content.
3. Unconfined compressive strength decreases with increase in fly ash content as well as increases in compaction delay.
4. With addition of lime to soil fly mix increases the strength at no compaction delay, maximum strength is achieved by adding 5% lime to 80% soil-20% fly ash.
5. As the compaction delay increases strength of soil fly ash lime mix decreases.

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