Stabilization of Black Cotton Soil using Alkali Activated Fly Ash

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Abstract

This research work presents the efficacy of sodium based alkaline activators and flies ash as an additive in improving the engineering characteristics of Black cotton soils. Sodium hydroxide concentration of 2 molal is used as activator. The black cotton soil behavior was studied in addition of different percentage of fly ash such as 5%, 10%, 15%, 20%, 25% & 30%. The activator with fly ash percentages of 5%, 10%, 15%, 20%, 25% and 30% relatively to the total solids. The Atterberg limits, specific gravity, unconfined compressive strength and Standard Proctor's compaction tests were performed on expansive clay soil. The results are indicated that in addition of fly ash with Alkali Activator solution with different concentrations reduces the liquid limit and plasticity index and increases the plastic limit of the Black Cotton soil. The optimum moisture content (OMC) and maximum dry density (MDD) curves indicate that addition of fly ash with Alkali Activator solution with different concentration increases the OMC but decreases the maximum dry density of the Black Cotton Soil. Increase in the Unconfined Compression Strenght was observed with increase in the percentage of Fly Ash. With increase in the percentage of fly ash with increasing concentration of Alkali Activator, unconfined compression strength was increased with the curing period.

Keywords: Black Cotton Soil, Fly Ash, Sodium Hydroxide, Alkali Activated Fly Ash

I. INTRODUCTION

A. *Black Cotton Soil:*

Black Cotton Soils also known as swelling soils or shrink-swell soils are the terms applied to those soils, which have a tendency to swell and shrink with the variation in moisture content. Expansive soil and bedrock underlie more than one third of world's land surface. These types of soils are generally found in arid and semi-arid regions of the world. Black cotton soils are mainly found over the Deccan lava tract (Deccan Trap) including Maharashtra, Madhya Pradesh, Gujarat, Andhra Pradesh and in some parts of Odisha, in the Indian sub-continent.

B. *Fly Ash:*

Fly ash is the squander material, which is the removed from the vent gasses of a coal terminated heater. These have close likeness with the volcanic fiery debris, which were utilized as pressure driven concretes as a part of old ages. These volcanic cinders were considered as one of the best pozzolans utilized till now as a part of the world.

C. *Alkali Activated Fly Ash:*

Preparation of alkali-activated fly ash by using 2 Molal sodium hydroxide solutions. Sodium Hydroxide at various Molals.(i.e 2M, 2.5M & 3M). Its Molecular weight is 40gm. (1M=40gm). 1 mole sodium hydroxide was prepared by adding 40gm of sodium hydroxide (flakes) to 1 litre of distilled water.

II. LITERATURE REVIEW

Pandian et al. (2001) had tried to improve the expansive soil stabilised with class –F Fly fiery remains and found that the fly ash could be a compelling admixture (around 20%) to enhance the CBR of Black cotton soil (around 200%) fundamentally.
Sabat et al. (2005) observed that fly ash with marble dust can enhance the engineering properties of expansive soil and the ideal extent of marble dust: fly ash: soil was 15: 20: 65.

Buhler et al. (2007) studied the stabilization of black cotton soils utilizing Class C fly ash and lime. The reduction in direct shrinkage was better with lime stabilization when contrasted with same % of Class C fly ash.

Sarat kumar das and Parthi kumar parthi (2013) Evaluate that if the alkali activation of waste materials has become an important area of research in many laboratory because it possible to use these materials to synthesize inexpensive and ecology like fly ash cement NaCl.

III. MATERIALS USED

A. *Black Cotton Soil:*

Black cotton soil is collected at the depth of 1.5m from ground level from locations near by Navalgund. The index and engineering properties of Black Cotton soil is determined as per the IS code 2720 (1974).

B. *Fly Ash:*

The Fly Ash is collected from RTPS at Raichur.

C. *Activator Solution:*

Sodium hydroxide available in two forms i.e pallets and flakes. Sodium Hydroxide (Flakes) is procured from Chennai. Molecular weight of NaOH is 40gm. So, 2Molal sodium hydroxide was prepared by adding 80gm of sodium hydroxide (flakes) to 1 litre of distilled water.

Table – 1
Properties of Black cotton soil

Test	*Result*
Clay	*58%*
Silt	*42%*
Liquid limit (%)	*84.50%*
Plastic limit (%)	*33%*
Plasticity index (%)	*51.50%*
Specific gravity	*2.53*
MDD (gm/cc)	*1.29 gm/cc*
OMC (%)	*31%*
Free swell	*100% (very high)*
IS - Classification	*CH*
Unconfined Compression Strenght	*49 kPa*

IV. METHODOLOGY

For Consistency limit test, Compaction test and UCS test: BC Soil + (from 5% to 30% at 5% intervals) fly ash by weight of total solids + 2 molal alkali activator by weight of total solids. For UCS test Curing period of 0 day, 7 days and 28 day.

Table – 2
The effect of adding Fly Ash on properties of Black Cotton Soil.

Sl No	*Materials*	*Liquid Limit (%)*	*Plastic limit (%)*	*Plasticity Index (%)*	*MDD (gm/cm^2)*	*OMC (%)*
1	*Soil + 5% FA*	*77.2*	*30.82*	*46.38*	*1.32*	*32.81*
2	*Soil + 10% FA*	*76.21*	*32.1*	*44.11*	*1.46*	*31.8*
3	*Soil + 15% FA*	*75.36*	*34.65*	*40.71*	*1.62*	*30.5*
4	*Soil +20% FA*	*74.22*	*37.58*	*36.64*	*1.79*	*27.6*
5	*Soil + 25% FA*	*72.61*	*39.76*	*32.85*	*1.95*	*26.1*
6	*Soil + 30% FA*	*70.62*	*42.18*	*28.44*	*2.26*	*23.92*

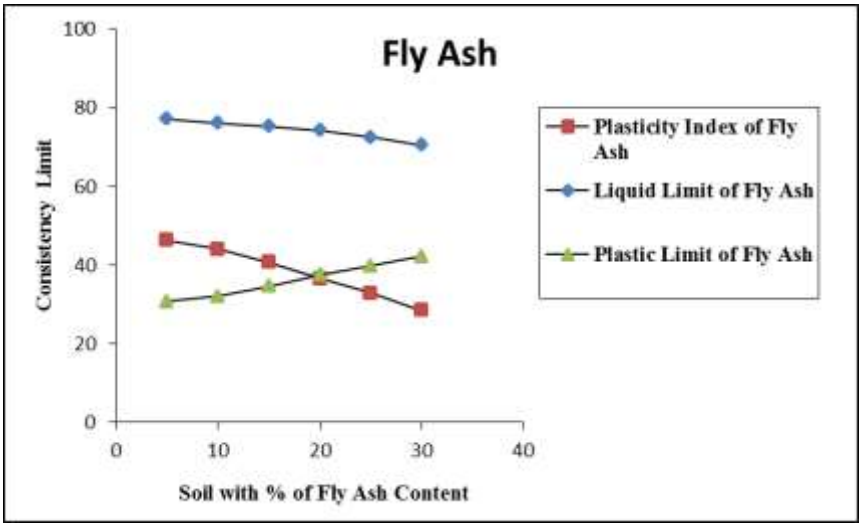

Fig. 1: % of Fly Ash Content versus Consistency limit.

From Table No 2, it can be shown that the variation of Consistency limits at different percentage of Fly Ash contents for black cotton soil. Liquid limit decreases from 77.2% to 70.62%, plastlic limit increases from 30.82% to 42.18% and plasticity index decreases from 46.38% to 28.44% respectively for fly ash content varying from 5% to 30% and the same is shown in fig 1.

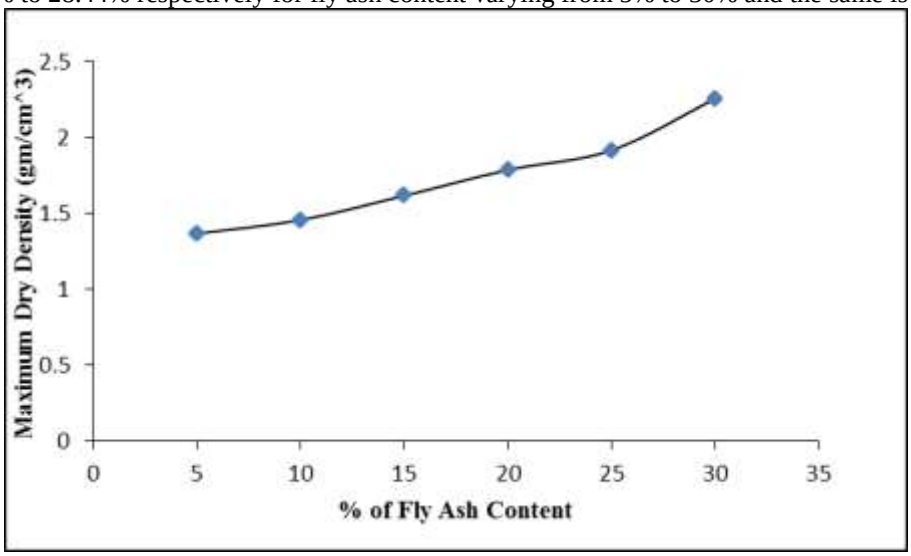

Fig. 2: % of Fly Ash Content versus MDD (gm/cm^3)

From Fig 2, it can be shown that, the maximum dry density increases from 1.37 gm/cm^2 to 2.26 gm/cm^2 respectively for fly ash content increase from 5% to 30%.

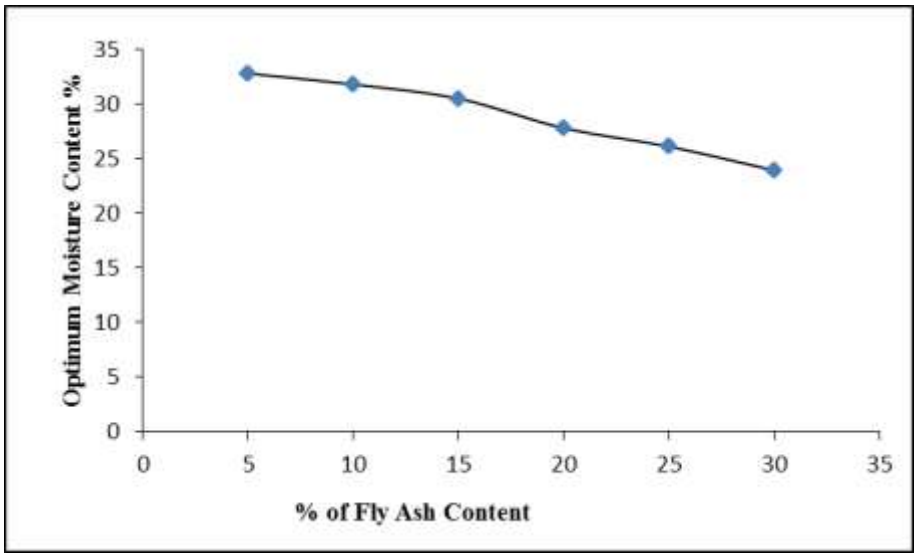

Fig. 3: % of Fly Ash Content versus OMC %

From Fig 3, it can be shown that, the Optimum moisture content decreases from 32.81% to 23.92% respectively for fly ash content increase from 5% to 30%.

Table – 3
UCS Results of various % of Flyash and no.of curing periods in days.

% of FA & Curing Periods in days	*5% (kPa)*	*10% (kPa)*	*15% (kPa)*	*20% (kPa)*	*25% (kPa)*	*30% (kPa)*
0	*90.05*	*100.84*	*150.42*	*220.62*	*275.8*	*314.75*
3	*98.21*	*104.52*	*156.24*	*228.51*	*304.07*	*324.47*
7	*108.79*	*117.92*	*190.08*	*245.78*	*319.89*	*361.31*
14	*124.22*	*150.96*	*227.06*	*283.64*	*337.04*	*377.74*
28	*153.25*	*172.88*	*262.52*	*302.84*	*365.9*	*405.66*

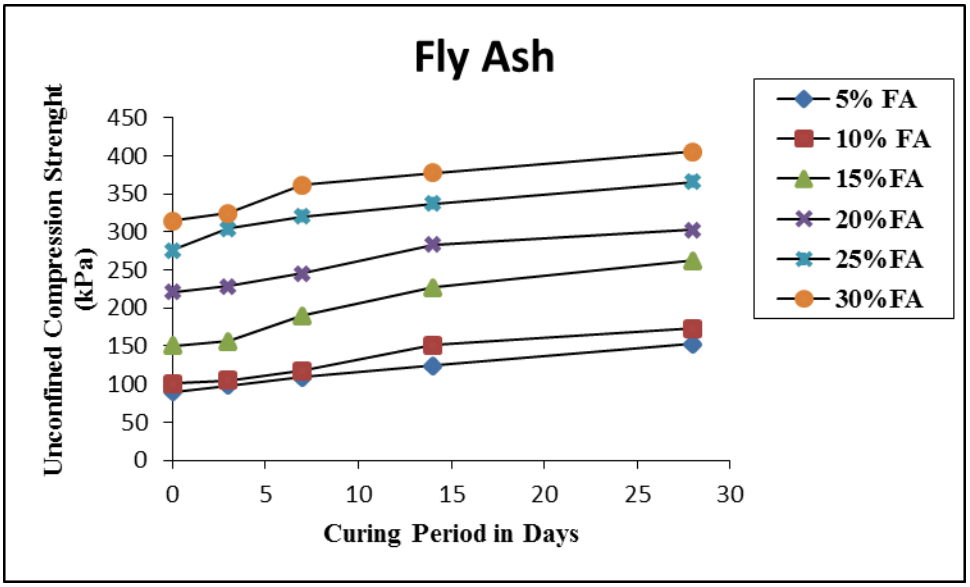

Fig. 4: Curing Period Versus UCS (kPa)

From Fig 4, it can be shows that variation of unconfined compression strength with curing period for black cotton soil samples with different percentage of fly ash under unsoaked condition.The unconfined compression strength increases from 90.05 to 153.25 kPa, 100.84 to 172.88 kPa, 150.42 to 262.52kPa, 220.62 to 302.84 kPa, 275.8 to 365.9 kPa and 314.75 to 405.66kPa with curing period varying from 0 to 28 days for fly ash content 5%, 10%, 15%, 20%, 25% and 30% respectively.

Table – 4

The effect of adding Alkali Activated Fly Ash on properties of B.C. Soil.

Sl No	*Materials*	*Alkali Activators*	*Liquid Limit (%)*	*Plastic Limit (%)*	*Plasticity Index (%)*	*MDD (gm/cm^3)*	*OMC (%)*
1	*Soil+5%FA*	*2M*	*77.16*	*29.41*	*47.75*	*1.37*	*29*
2	*Soil+10%FA*	*2M*	*76.64*	*31.27*	*45.37*	*1.34*	*32.19*
3	*Soil+15%FA*	*2M*	*74.33*	*33.88*	*40.45*	*1.33*	*34.16*
4	*Soil+20%FA*	*2M*	*72.57*	*35.98*	*36.59*	*1.32*	*36.41*
5	*Soil+25%FA*	*2M*	*70.53*	*38.73*	*31.8*	*1.30*	*37.41*
6	*Soil+30%FA*	*2M*	*68.21*	*41.79*	*26.42*	*1.26*	*39.79*

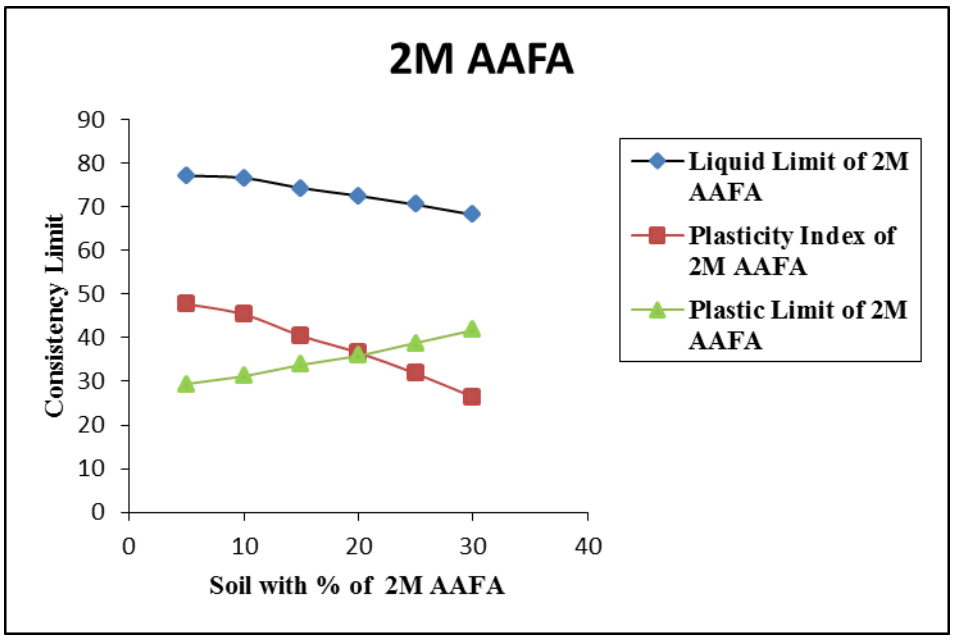

Fig. 5.11: Consistency Limit versus % of 2M AAFA

From Table No 5.4, it can be shown that the variation of Consistency limits at different percentage of Fly Ash contents for black cotton soil. Liquid limit decreases from 77.16% to 68.21%, plastlic limit increases from 29.41% to 41.79% and plasticity

index decreases from 47.75% to 26.42% respectively for fly ash content varying from 5% to 30% and the same is shown in fig 5.11.

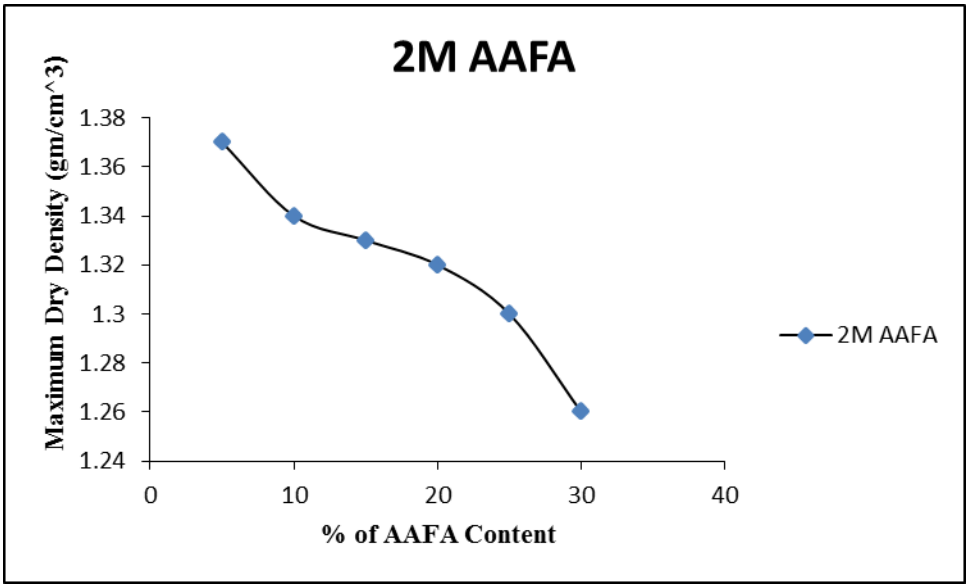

Fig. 5.12: % of Fly Ash Content versus MDD (gm/cm^3)

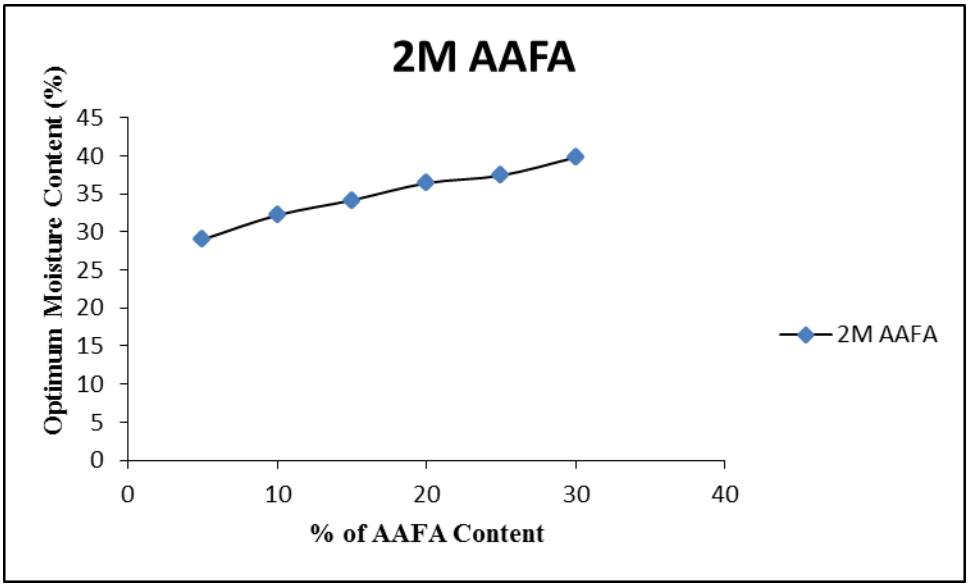

Fig. 5.13: % of Fly Ash Content versus OMC (%)

From Fig 5.12 and Fig 5.13, it can be shown that increasing the varying percentage of fly ash content with 2Molal of Alkali Activator solution, the maximum dry density decreases and optimum moisture content increases.

Table - 5.7
UCS Results of various % of 3M AAFA and no.of curing periods in days.

% of 3M AAFA & Curing Periods in days	*5% (kPa)*	*10% (kPa)*	*15% (kPa)*	*20% (kPa)*	*25% (kPa)*	*30% (kPa)*
0	*109.2*	*128.82*	*234.1*	*286.33*	*381.06*	*436.27*
3	*130.38*	*135.83*	*264.96*	*299.96*	*400.54*	*491.61*
7	*139.18*	*152.1*	*387.15*	*423.25*	*439.57*	*533.06*
14	*163.66*	*203.1*	*417.65*	*459.21*	*489.64*	*570.97*
28	*198.17*	*221.42*	*497.06*	*553.66*	*629.23*	*672.28*

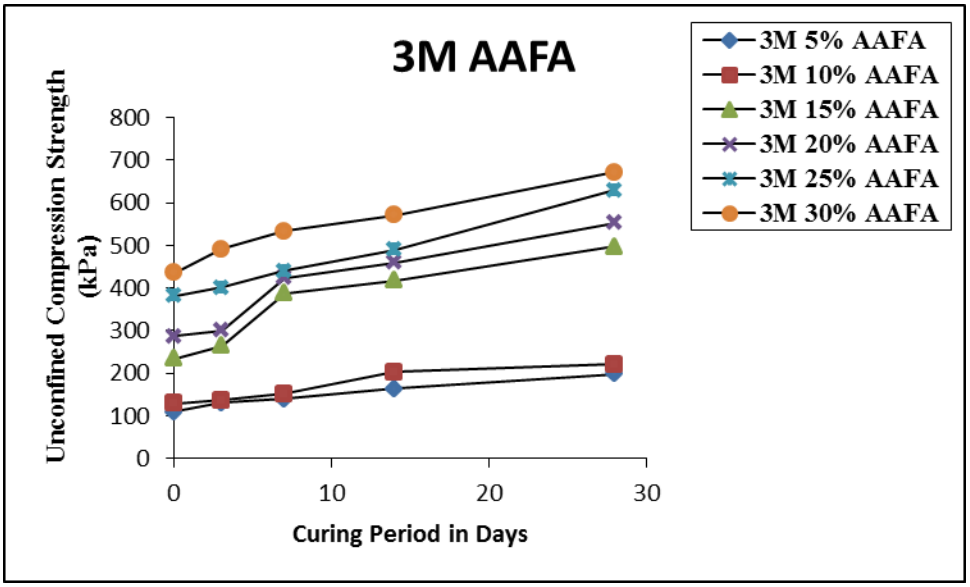

Fig. 5.40: Curing Period Versus UCS (kPa)

From Fig 5.40, it can be shows that variation of unconfined compression strength with curing period for black cotton soil samples with different percentage of fly ash under un soaked condition. The unconfined compression strength increases from 109.2 to 198 kPa, 128.82 to 221.42 kPa, 234.1 to 497.06 kPa, 286.33 to 553.66 kPa, 381.06 to 629.23 kPa and 436.27 to 672.28 kPa with curing period varying from 0 to 28 days for fly ash content 5%,10%,15%,20%,25% and 30% respectively.

V. CONCLUSION

1) With the increase in percentage of Fly Ash, liquid limit decreases, plastic limit increases and plasticity index decreases.
2) Maximum Dry Density Decreases and Optimum water content with increase in the concentration of the alkali activated fly ash.
3) Increase in the unconfined compression strength was observed with increase in the percentage of fly ash.
4) With increase in the percentage of fly ash with increasing concentration of alkali activator, unconfined compression strength was increased with the curing period.
5) Soil treated with Alkali Activated Fly Ash gives better strength than the fly ash treated with soil.

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