INVESTIGATION ON STABILIZATION OF EXPANSIVE SOIL BY USING ALKALI ACTIVATED FLY ASH

G.Jyothi[1], M. Rama Krishna[2]

[1]*M.Tech Scholar, Department of Civil Engineering, Sri Sunflower College of Engineering & Technology, Prakasam, Andhra Pradesh, India*
[2] *Assistant Professor, Department of Civil Engineering, Sri Sunflower College of Engineering & Technology, Prakasam, Andhra Pradesh, India*

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ABSTRACT: Stabilization of Expansive soil is a matter of great distress now a day's. almost 51.6 million hectares of land area in India are enclosed with Expansive soil (mainly Black Cotton soil).The assets of these expansive soils in genera l is that they are very hard when in dry state but they lose all of their strength when in wet state. In light of these assets of expansive soils these soils pose problems worldwide that serve as challenge to overcome for the Geotechnical engineers. usually fly ash is use to increase the stability of structure but in this investigation work presents the efficiency of sodium based alkaline activators and class F fly ash as an additive in improving the engineering personality of expansive Black cotton soils. Sodium hydroxide concentrations of 10, 12.5 and 15 molal along with 1 Molar solution of sodium silicate were used as activators. The activator to ash ratio was kept between 1 and 2.5 and ash percentages of 20, 30 and 40% comparatively to the total solids. The effectiveness of this binder is tested by conducting the Unconfined compressive strength (UCS) at curing periods of 3,7 and 28 days and is compare with that of a regular fly ash based binder and also the most effective mixtures were analyzed for mineralogy with XRD. Suitability of alkaline activated fly ash mix as a grouting material is also ascertained by studying the rheological characteristics of the grout such as setting time, density and viscosity and is compared with that of common cement grouts. Results shows that the fluidity of the grouts correlate very well with UCS with an increase in the former resulting in a decrease in the latter.

1. INTRODUCTION

1.1Expansive soils

Expansive soils also are known as swelling soils or shrink-swell soils are the phrases generally carried out to those soils which will be inclined to swell and cut back with variant in moisture content. As a result of which sizeable misery within the soil take place which inflicts intense harm to overlying shape. throughout monsoon's those soils eat water swell and turn out to be tender and their potential to undergo water is to be decreased, while in drier seasons these soils shrinks and emerge as harder due to the evaporation of water. these styles of soils are generally found in arid and semi-arid regions of the world and are taken into consideration as a capability herbal hazard, which if now not handled nicely can reason huge damages to now not handiest to the structures built upon them however also can purpose extreme loss of human lifestyles too. the annual value of damages to the civil engineering systems resulting from those soils are anticipated to be £ 180 million inside the UK., $ 1200 million inside the U.S. and plenty of billions of dollars internationally.

Expansive soils mostly situated on the Deccan lava tract (Deccan trap) such as Maharashtra, Madhya Pradesh, Gujarat, and Andhra Pradesh and in some parts of Odisha within the Indian sub-continent. Black cotton soils also are located in river valley of Tapi, Krishna, Godavari Narmada and in some parts of north western fraction of Deccan Plateau and in the top components of Krishna and Godavari. Basically these soils are residual soils left on the region in their formation after chemical decomposition of the rocks consisting of basalt and lure. Also these types of soils are formed due to the weathering of igneous rocks and the cooling of lava after a volcanic eruption. These soils are rich in lime, iron, magnesia and alumina however be deficient in the phosphorus, nitrogen and normal count number.

Their color varies from black to chestnut brown and essentially includes excessive percent of clay sized particles. On a median 20% of total land area blanketed with the expansive soils. due to their dampness this soils are suitable for dry farming and are fit for growing cottons, cereals, rice, wheat, jowar, oilseeds, citrus end result and vegetables, tobacco and sugarcane. During the previous few long time harm because of swelling motion has been surely determined inside the semiarid areas of India inside the shape of cracking and breakup of pavements, roadways, constructing foundations, slab-on-grade contributors, channel and reservoir linings, irrigation structures, waterlines, and sewer traces.

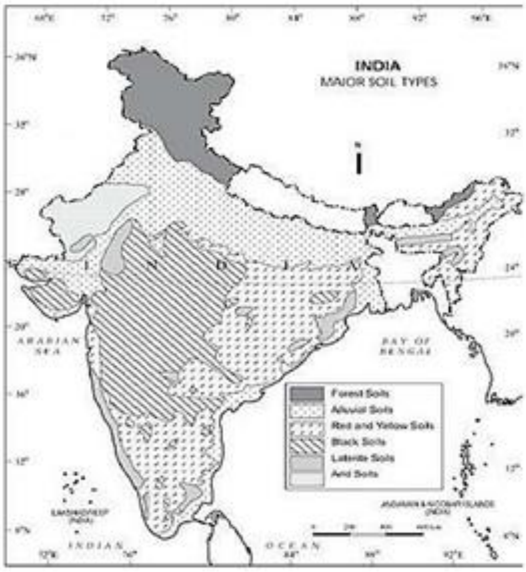

Figure 1 Major Soil Types in India

1.2 Alkali Activated Fly ash

Alkaline activation is a chemical method in which a chalky alumina-silicate such as fly ash is mixed with an alkaline activator to create a paste capable of setting and hardening within a reasonably short period of time. The alkaline activation of fly ash is consequently of great interest in the context of new and environmentally friendly binders with properties similar to or that improved on the characteristics of conventional materials. In general terms alkaline activation is a reaction between alumina-silicate materials and alkali or alkali earth substances namely: ROH, $R0H_2$, $R2CO_3$, R_2S, Na_2S0_4, $CaS0_4.2H_20$, R_2Si0_2,

2. Methodology Adopted

To evaluate the effect of the ash/soil ratio (by dry mass) on mechanical strength three different fly ash percentages regarding the total solids (soil + ash) weight, were used 20, 30 and 40%, corresponding to ash/soil ratios of 0.25, 0.43 and 0.67, with activator/total solids ratios of 0.15, 0.2 and 0.25. The details of the experimental specimens are shown in Table 6. the soil and the ash were previously homogenized before the activator was added to the mixture. After mixing for 3 min, the samples were cast into 50-mm moulds by tapping the moulds on the lab counter, which were then left in a sealed container. Since the behaviour of the mixtures was that of a viscous fluid, no density control was used during the preparation of the samples. However, when removed from the moulds, every sample was weighted, and an average unit weight of 20kN/m was obtained regardless of the fly ash percentage in the mixture. The 15 molal mixtures showed a very high viscosity which made the preparation and handling process more difficult than with the remaining concentrations to a point where this factor should be considered when designing future studies and/or applications. This effect is related to the Si02: Na20 mass ratio of the silicate + hydroxide solution which for the 15 molal activator is approximately 1, making the metasilicate solution very unstable and favouring crystallization. This Si02: Na20 mass ratio was in the original silicate solution approximately 2 but the addition of the hydroxide solution reduced it significantly especially in the 15 molal mixtures. After 48 hours, the samples were removed from the moulds and wrapped in cling film and left at ambient temperature and humidity conditions (50-60 % RH and 32-35° C). Immediately before testing, at the ages of 3, 7 and 28 days, the samples were trimmed to 100 mm long and tested for unconfined compressive strength (UCS) on an Aimil hydraulic testing machine. Every single result obtained was the average of 3 tested samples. The details of the alkaline activator mixed soil specimens are shown in Table.

Curing time (Days)	Unconfined compressive strength (kPa)								
	F-15-20	F-15-30	F-15-40	F-20-20	F-20-30	F-20-40	F-25-20	F-25-30	F-25-40
3	104.2	99.52	82.31	86.61	122.56	92.10	46.41	42.30	38.39
7	281.23	220.1	145.60	113.20	132.80	101.68	53.61	49.86	47.92
28	362.61	278.3	253.92	140.20	156.26	126.82	114.63	98.63	88.46

Table shows the UCS values of all samples treated with fly ash, obtained after 3, 7 and 28days curing. It is evident from the results depicted in table that the mix F-20-30 is giving more 3 day strength as compared to other mixes. But the mix F-15-20 is giving more strength at 7 day and 28 day curing as compared to others. Strength of the mix F-25-40 obtained after 3, 7 and 28 days curing is the least among all others. The 3 day strength of F-20-30 is near about 2.2 times more than that of F-25-40. Similarly the strength obtained after 7 day and 28 day curing of the mix F-15-20 is about 5 times and 3 times more than that obtained from mix F-25-40. The variations of strength of the mix obtained with the days of curing are shown in a bar chart graph in figure 2, 3 and 4.

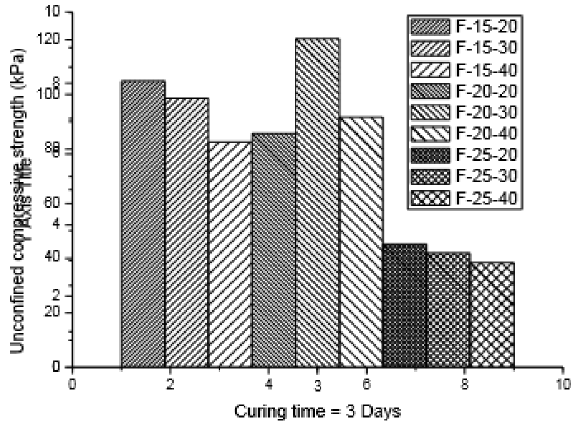

Figure 2. Bar chart showing the UCS results of Fly ash Samples after 3 days of curing

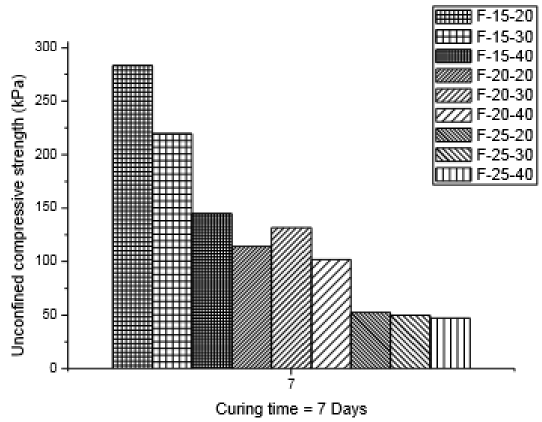

Figure 3. Bar chart showing the UCS results of Fly ash Samples after 7 days of curing

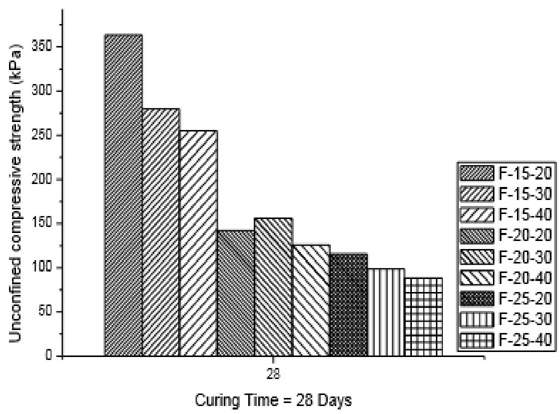

Figure 4. Bar chart showing the UCS results of Fly ash Samples after 28 days of curing

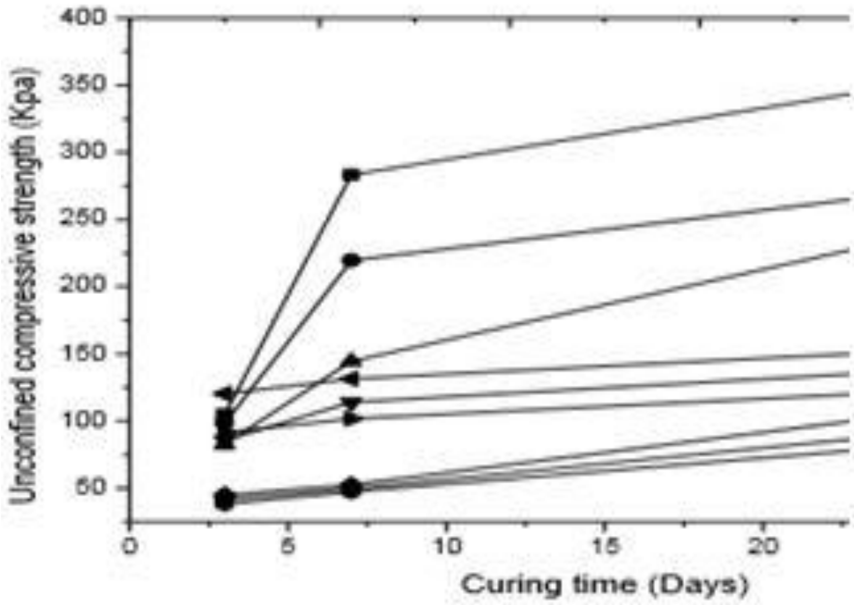

Figure 5. UCS results of all Fly ash Samples

2.1 Alkalic Activated Fly ash Samples

Table 1. UCS results of all 10 molal samples

Curing time (Days)		3	7	28
Unconfined compressive strength (kPa)	AF-100-20-15	195.46	253.32	436.63
	AF-100-30-15	175.95	179.24	195.23
	AF-100-40-15	140.51	131.41	128.9
	AF-100-20-20	311.58	350.83	407.7
	AF-100-30-20	392.7	462.64	580.62
	AF-100-40-20	322.8	546.88	810.02
	AF-100-20-25	103.97	130.13	238.77
	AF-100-30-25	94.71	146.92	215.77
	AF-100-40-25	85.42	112.03	232.77

Table 2. UCS results of all 12.5 molal samples

Curing time(Days)		3	7	28
Unconfined compressive strength (kPa)	AF-125-20-15	114.59	220.1	364.32
	AF-125-30-15	158.87	152.8	221.54
	AF-125-40-15	187.08	250.27	399.24
	AF-125-20-20	307.85	230.25	548.78
	AF-125-30-20	196.93	293.83	590.78
	AF-125-40-20	287.42	419.2	977.09
	AF-125-20-25	128.77	154.83	317.55
	AF-125-30-25	114.93	179.89	555.47
	AF-125-40-25	113.76	192.29	852.17

Table 3. UCS results of all 15 molal sample

Curing time (Days)		3	7	28
Unconfined compressive strength (kPa)	AF-150-20-15	288.17	339.7	579.28
	AF-150-30-15	247.41	428.28	603.32
	AF-150-40-15	160.75	503.98	643.86
	AF-150-20-20	207.72	361.06	396.63
	AF-150-30-20	239.99	450.03	715.4
	AF-150-40-20	171.61	503.98	643.86
	AF-150-20-25	111.24	138.52	182.15
	AF-150-30-25	98.43	181.89	465.24
	AF-150-40-25	75.63	256.65	296

Table 1 shows the variation of strength obtained for 10 molal activator content and 20, 30 and 40% fly ash content mixed soil samples, after 3, 7 and 28 days curing periods. The variations are also shown in Figure 6, 7, 8 and 9 shows the gain in strength of all 10 molal mixes after 3, 7 and 28 days respectively in bar graph form.

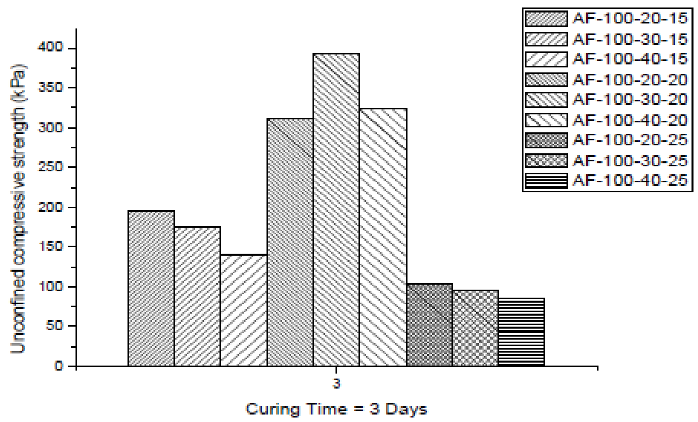

Figure 6. UCS results of 10 molal sample (3 Days Curing)

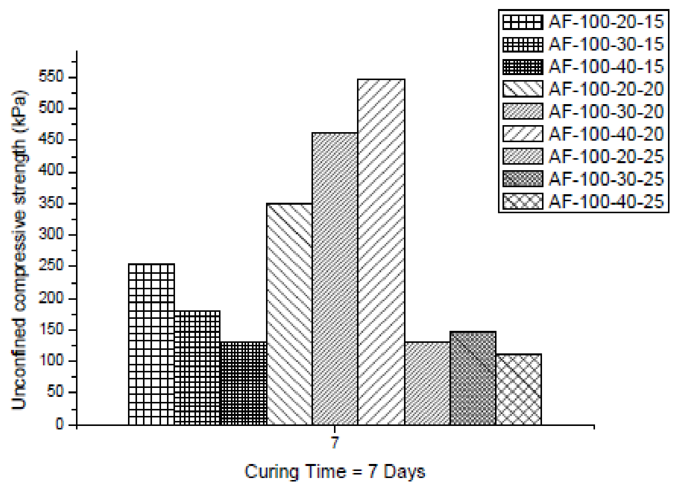

Figure 7. UCS results of 10 molal sample (7 Days curing)

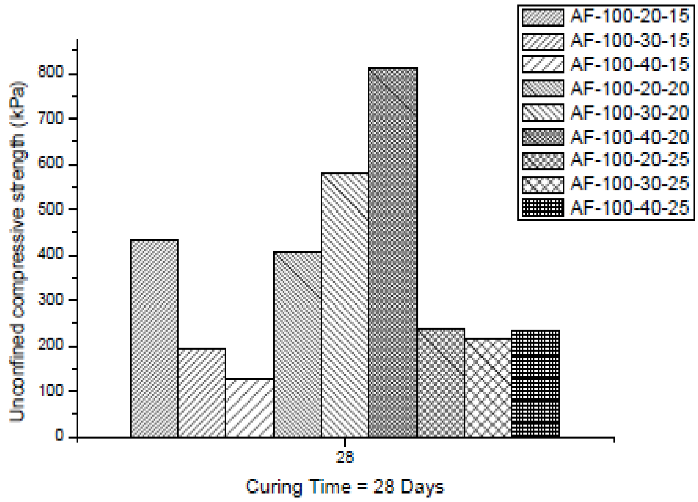

Figure 8. UCS results of 10 molal sample (28days curing)

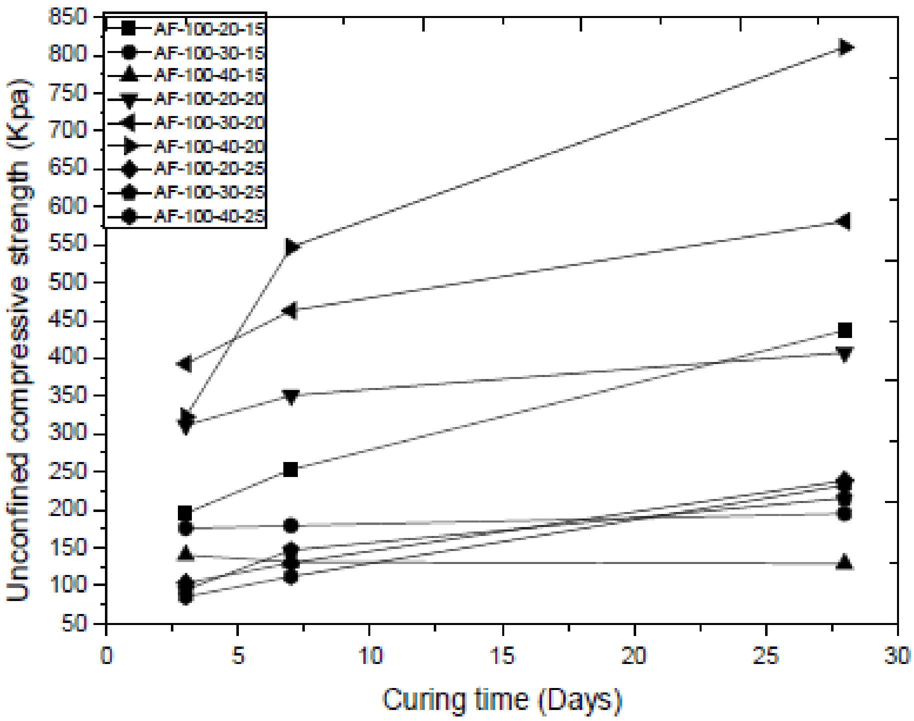

Figure 9. UCS results of all 10 molal sample

Table 2 shows the variation of strength obtained for 12.5 molal activator content and 20, 30 and 40% fly ash content mixed soil samples, after 3, 7 and 28 days curing periods. The variations are also shown in Figure 10, 11, 12 and 13 shows the gain in strength of all 12.5 molal mixes after 3, 7 and 28 days respectively in bar graph form. From the tables and graphs it is evident that the 3 days strength is more in case of mix AF-125-20-20, while the 7 & and 28 days strength is more in case of mix AF-125-40-20. The least 3 days strength is exhibited by mix AF-125-40-25, while mix AF-125-30-15 exhibit least 7 days strength and mix AF-125-40-15 exhibit least strength after 28 days curing.

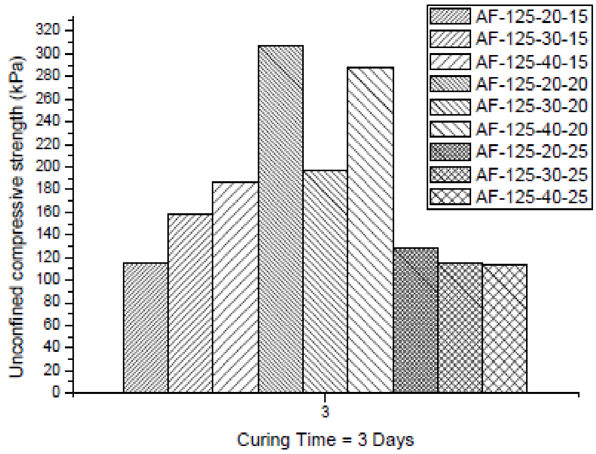

Figure 10. UCS results of 12.5 molal sample (3 Days curing)

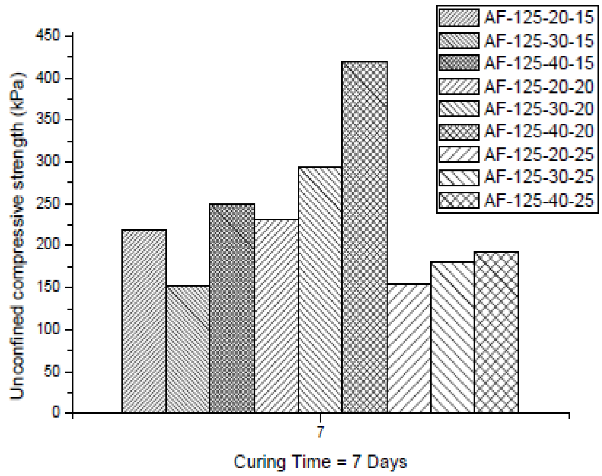

Figure 11. UCS results of 12.5 molal sample (7 Days curing)

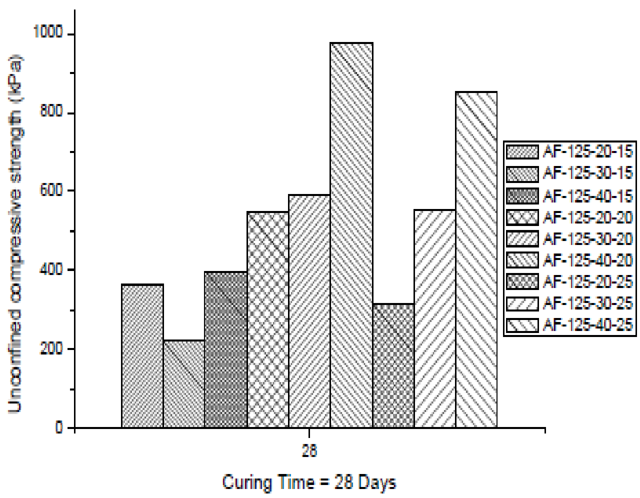

Figure 12. UCS results of 12.5 molal sample (28 Days curing)

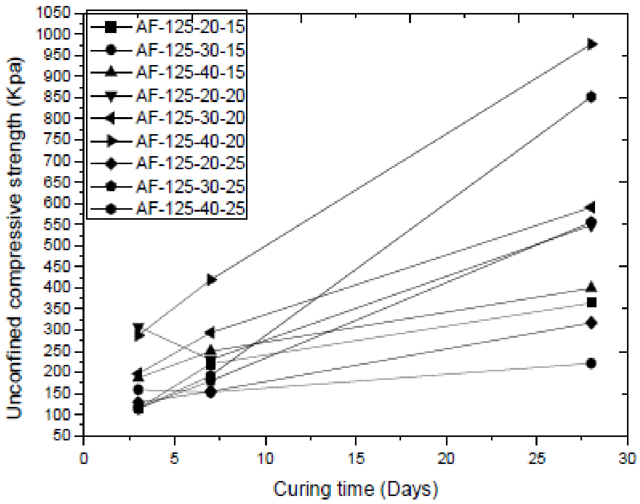

Figure 13. UCS results of all 12.5 molal sample

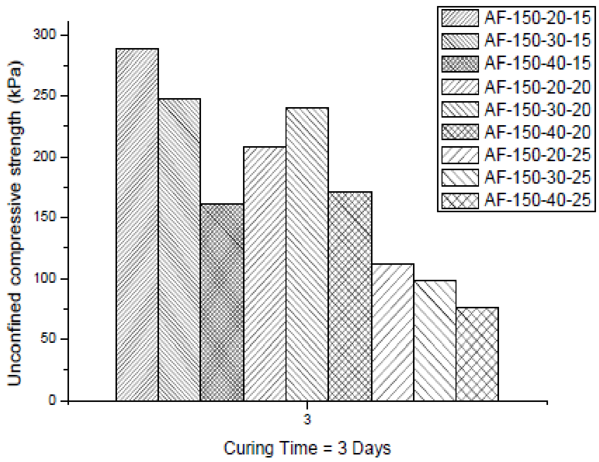

Figure 14. UCS results of 15 molal sample (3 Days curing)

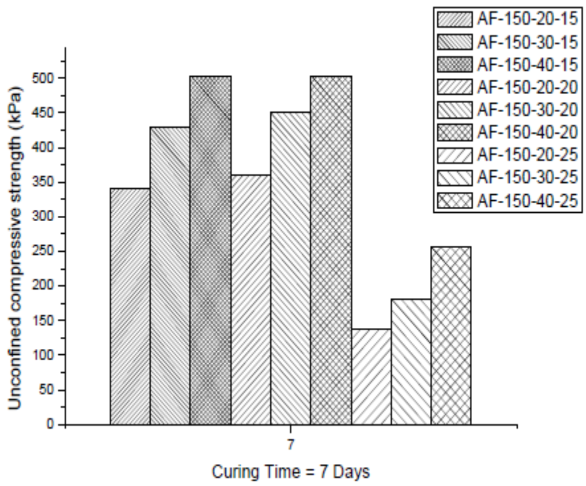

Figure 15. UCS results of 15 molal sample (7 Days curing)

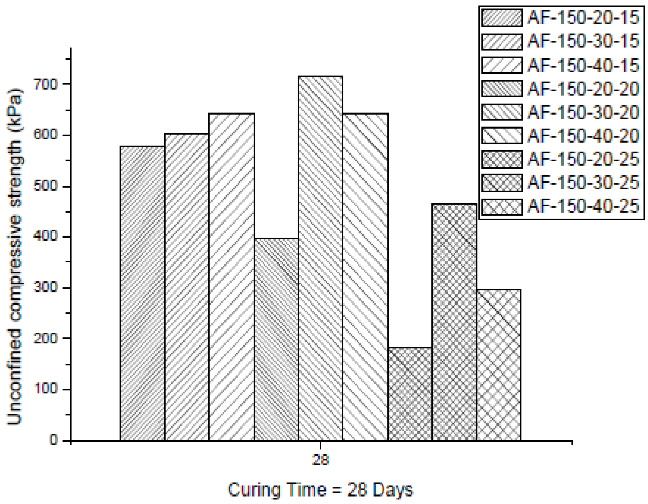

Figure 16. UCS results of 15 molal sample (28 Days curing).

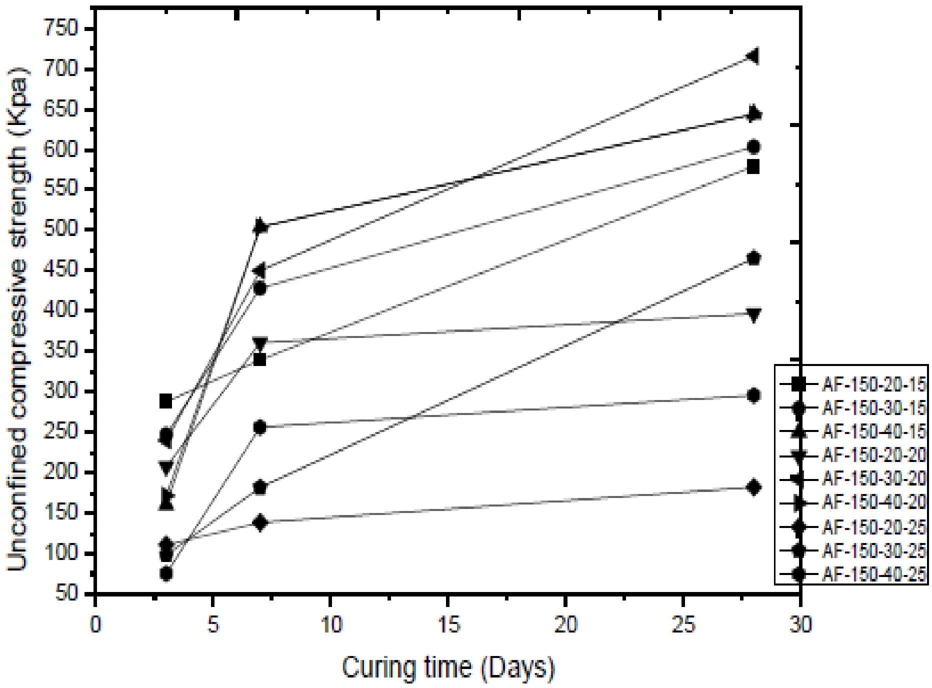

Figure 17 UCS results of all 15 molal Samples

The variation of strength obtained for 15 molal activator content and 20, 30 and 40% fly ash content mixed soil samples, after 3, 7 and 28 days curing periods is shown in Table 3.

The variations are also shown in Figure 14, 15, 16 and 17 shows the gain in strength of all 15 molal mixes after 3, 7 and 28 days respectively in bar graph form. From the tables and graphs it is evident that the 3 days strength is more in case of mix AF-120-20-15, while the 7 & and 28 days strength is more in case of mix AF-150-40-15 and mix AF-150- 40-20. The least 3 days strength is exhibited by mix AF-150-40-25, while mix AF-125-20-25 exhibit least strength after 7 and 28 days of curing.

Table 4 UCS results of all AAFA Samples

Name	Qu (kPa)	Name	Qu (kPa)	Name	Qu (kPa)
AF-100-20-15-3D	196.42	AF-100-20-15-7D	253.31	AF-100-20-15-28D	440.63
AF-100-30-15-3D	175.92	AF-100-30-15-7D	178.46+	AF-100-30-15-28D	192.43
AF-100-40-15-3D	141.521	AF-100-40-15-7D	132.41	AF-100-40-15-28D	129.92
AF-100-20-20-3D	312.52	AF-100-20-20-7D	352.86	AF-100-20-20-28D	406.50
AF-100-30-20-3D	392.70	AF-100-30-20-7D	463.64	AF-100-30-20-28D	582.61
AF-100-40-20-3D	322.86	AF-100-40-20-7D	546.88	AF-100-40-20-28D	812.26
AF-100-20-25-3D	104.26	AF-100-20-25-7D	130.47	AF-100-20-25-28D	238.76
AF-100-30-25-3D	94.68	AF-100-30-25-7D	146.73	AF-100-30-25-28D	214.82
AF-100-40-25-3D	85.42	AF-100-40-25-7D	115.56	AF-100-40-25-28D	236.72
AF-125-20-15-3D	115.56	AF-125-20-15-7D	219.23	AF-125-20-15-28D	364.53
AF-125-30-15-3D	160.6287	AF-125-30-15-7D	151.86	AF-125-30-15-28D	222.62
AF-125-40-15-3D	186.62	AF-125-40-15-7D	246.84	AF-125-40-15-28D	401.57
AF-125-20-20-3D	308.27	AF-125-20-20-7D	231.48	AF-125-20-20-28D	546.73
AF-125-30-20-3D	196.47	AF-125-30-20-7D	286.59	AF-125-30-20-28D	592.68
AF-125-40-20-3D	287.41	AF-125-40-20-7D	419.23	AF-125-40-20-28D	977.09
AF-125-20-25-3D	128.76	AF-125-20-25-7D	154.82	AF-125-20-25-28D	317.54
AF-125-30-25-3D	114.92	AF-125-30-25-7D	179.88	AF-125-30-25-28D	555.46
AF-125-40-25-3D	113.75	AF-125-40-25-7D	192.28	AF-125-40-25-28D	852.16
AF-150-20-15-3D	288.17	AF-150-20-15-7D	339.70	AF-150-20-15-28D	579.28
AF-150-30-15-3D	247.41	AF-150-30-15-7D	428.27	AF-150-30-15-28D	603.32
AF-150-40-15-3D	160.75	AF-150-40-15-7D	503.98	AF-150-40-15-28D	643.86
AF-150-20-20-3D	207.72	AF-150-20-20-7D	361.06	AF-150-20-20-28D	396.93
AF-150-30-20-3D	239.99	AF-150-30-20-7D	450.03	AF-150-30-20-28D	715.40
AF-150-40-20-3D	171.61	AF-150-40-20-7D	503.98	AF-150-40-20-28D	643.86
AF-150-20-25-3D	111.24	AF-150-20-25-7D	138.52	AF-150-20-25-28D	182.15
AF-150-30-25-3D	98.43	AF-150-30-25-7D	181.89	AF-150-30-25-28D	465.24
AF-150-40-25-3D	75.63	AF-150-40-25-7D	256.55	AF-150-40-25-28D	296.0

Table 4 gives the details of the activated mix casted and their corresponding strengths attained after 3, 7 and 28 days of curing. Among all the highest strength obtained after 3 days of curing was attained by the mix AF-150-30-20-3D, while the strength attained by mix AF-150-40-20-7D after 7 days of curing is more than all others. The mix AF-150-40-20-28D outperforms all in respect of strength attained after 28 days of curing.

Conclusions:

Based on the obtained results and discussion thereof following conclusions can be made.

•The unconfined compressive strength soil is found to vary with concentration of chemical in the activated fly ash and curing period.

•10 molal samples are giving better 3 and 7 days strengths than 12.5 and 15 molal samples, which make it economical as compared to 12.5 and 15 molal samples.

•Long term strength is more in case of 12.5 molal samples.

•Maximum 3 day strength attained by activated sample is 392.7 kPa, which is 3.25 times more than that attained by fly ash treated samples.

•Maximum 7 day strength attained by activated sample is 546.88 kPa, which is 2 times more than that attained by fly ash treated samples.

•Maximum 28 day strength attained by activated sample is 977.09 kPa, which is 2.7 times more than that attained by fly ash treated samples.

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