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A STUDY ON STRENGTH CHARACTRISTICS OF FLYASH WITH ADDITIVES

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***Abstract*- This paper presents the flyash Stabilization is usually based on reactions between flyash and chemical agents. In the present study, a laboratory testing program was done to investigate the strength properties of flyash with lime, PPC and Sodium silicate. Individual geotechnical properties of flyash were determined and then flyash was mixed with different proportions of lime (2-15%), Portland pozzolana cement (2-15%) and sodium silicate (1-5%). These mixes were tested to obtain optimum percentage of lime and sodium silicate. The variation of strength characteristics were also studied by conducting the tests like Unconfined Compressive Strength (UCS), Split Tensile Strength and California Bearing Ratio (CBR) for different curing periods 1, 3, 7 and 28 days for UCS and Split Tensile Strength and 3, 7 & 28 days for CBR. The results are complied in a graphical form to observe the trends for various parameters. The results show remarkable improvement in strength characteristics at compacted condition.**

***Index Terms*- Flyash,lime,ppc,sodiumsilicate, unconfined compressive strength, California bearing ratio and split tensile strength.**

I. INTRODUCTION

Flyash is a fine, glass powder obtained from burning of coal during the production of electricity. These micron-sized earth elements consist primarily of silica, alumina and iron. In India, about 70 million tonns of coal ash is produced per year from burning about 200 million tonns of coal per year for electric power generation. Coal-ash management poses a serious environmental problem for India and requires a mission-mode approach. Disposal of wastage requires costly land at thermal power plants and the transport of flyash to the ash ponds entail heavy expenditure. Considerable research and development work have been undertaken across the country towards confidence building and developing suitable technologies for disposal and utilization of flyash in construction industries.

At present about 10% Ash is utilized in Ash dyke construction and land filling and only about 3% of Ash is utilized in other construction industries. This is very much in contrast with 80% or more flyash used in developed countries for the manufacture of bricks, cellular concrete blocks, road construction, land fill application, ceramics, agriculture, insulating bricks, recovery of metals and dam constructions etc. Currently, about one acre land is needed for one metric tonnes of Ash disposal.

Highway engineers are utilizing bulk quantities of flyash into embankment and road construction. Fly ash settles very negligible amount during construction period and not afterwards. Its lesser density is suitable for high embankments. Lime stabilized flyash gains cementitious properties due to formation of silicates and aluminate hydrates at the time of pozzolanic reaction. Due to cementations properties, lime stabilized flyash gain in strength which is the better alternative for stable sub-grade or sub-base. Cement stabilized flyash has better performance in load carrying capacity and reduction of heave compared to lime or un-stabilized flyash sub-grade. By using additives like sodium silicate can increase the strength of lime stabilized flyash.

Research on agricultural uses of flyash has been going on in universities and research institutes across the country for several years. The same flyash that causes harm when it settles on leaves can prove beneficial when applied scientifically to agricultural fields. It can be a soil modifier and enhance its moisture retaining capacity and fertility. It improves the plant's water and nutrient uptake, helps in the development of roots and soil-binding, stores carbohydrates and oils for use when needed, protects the plants from soil-borne diseases, and detoxifies contaminated soils

The present study is about utilization of lime, PPC and sodium silicate in stabilization of flyash. The study involves performing a series of C.B.R, U.C.S and Split tensile strength tests on the flyash-lime-sodium silicate mixtures:

1. To identify the improvement in strength characteristics like UCS, Split Tensile Strength and CBR values.
2. To identify optimum dosage of sodium silicate.
3. To identify optimum curing period.
4. To study sodium affects on the above strength characteristics.

To suggest these stabilized materials in geotechnical engineering applications.

In geotechnical works huge quantities of flyash can be utilized. As per Trehan (1996) in 1992, approximately 460 million tonnes of flyash was produced worldwide out of which about 153 million tonnes (33%) were utilized. Structural or land fill embankment and filler for mines, quarries or pits come under geotechnical engineering applications. Considering other geotechnical application such as pavements, stabilization of soils, waste fills liner etc. About 65% of the total utilization is through geotechnical applications.

II. MATERIALS AND METHODOLOGY

A. Materials

The materials used in this investigation are Flyash, Lime, sodium silicate Portland Pozzolana Cement. Flyash is collected from GMR power corporation vemagiri in rajamundry and laboratory study was carried out for salient geotechnical characteristics of such as grading, Atterberg limits, compaction and strength. The properties of flyash shown in table 1.Table No: 1

Property	Values
Gravel (%)	0
Sand (%)	28
Fines (%)	72
a.Silt(%)	72
b.Clay(%)	0
Liquid Limit (%)	28
Plastic Limit (%)	NP
Specific gravity	2.1
IS heavy Compaction	
Optimum moisture content (%)	21.0
Maximum dry density (g/cc)	1.28
California bearing ratio	3

Properties of Portland Pozzolanic Cement

S.No	Characteristics	PPC
1.	Standard Consistency (%)	31
2.	Weight per bag (Kg)	50
3.	Initial setting time (min)	180
4.	Final setting time(min)	292
5.	Specific gravity	3.13
6.	Fineness (As retained on sieve IS: 9 micron) (%)	2.00
7.	Ultimate compressive strength of average of three standard cement mortar cubes	
a.	At the age of 3 days (Mpa)	24.6
b.	At the age of 7 days (Mpa)	35.0
c.	At the age of 28 days (Mpa)	55.40

B. Methodology

The following tests were conducted on the flyash. The index and engineering properties of flyash were determined.

- Grain Size Analysis
- Atterberg's Limits
- Specific Gravity
- Proctor's Compaction Test
- Unconfined Compressive Strength Test
- California Bearing Ratio Test
- Split Tensile Strength

III.RESULTS AND DISCUSSION

Compaction Characteristics of Flyash Lime Mixes:

LIME (%)	OMC (%)	MDD (g/cc)
0	21	1.28
2	21.4	1.26
4	21.8	1.24
6	22.3	1.23
8	22.8	1.21
10	23.3	1.18
12	23.6	1.16
15	24.0	1.14

Variation of OMC for lime-sodium silicate- flyash mixes:

Lime (%)	Sodium Silicate				
	1%	2 %	3 %	4%	5 %
8	22.9	23.1	23.3	23.4	23.4
10	23.4	23.6	23.8	24	24.1
12	23.8	24	24.2	24.3	24.5
15	24	24.2	24.4	24.5	24.6

Variation of MDD for lime-sodium silicate- flyash mixes:

Lime (%)	Sodium Silicate				
	1 %	2 %	3 %	4 %	5 %
8	1.2	1.19	1.18	1.18	1.17
10	1.17	1.16	1.15	1.14	1.14
12	1.15	1.13	1.12	1.11	1.09
15	1.13	1.11	1.1	1.09	1.08

Unconfined Compressive strength of flyash lime Mixes(kPa): Unconfined Compressive strength of flyash and different percentages of PPC (kPa):

PPC %	Curing period (days)			
	1	3	7	28
2	180	330	643	899
4	276	608	1028	1850
6	413	1096	2075	3422
8	468	1356	2342	3785
10	580	1854	3099	4634
12	692	2658	3874	5742
15	821	3595	5026	6586

Unconfined Compressive strength of flyash, 8% lime and different percentages of Sodium silicate (kPa):

Sodium silicate (%)	Curing period (days)			
	1	3	7	28
1	606	1002	1402	2327
2	812	1524	2276	3624
3	553	1260	2045	3026

Unconfined Compressive strength of flyash, 10% lime and different percentages of sodium silicate (kPa):

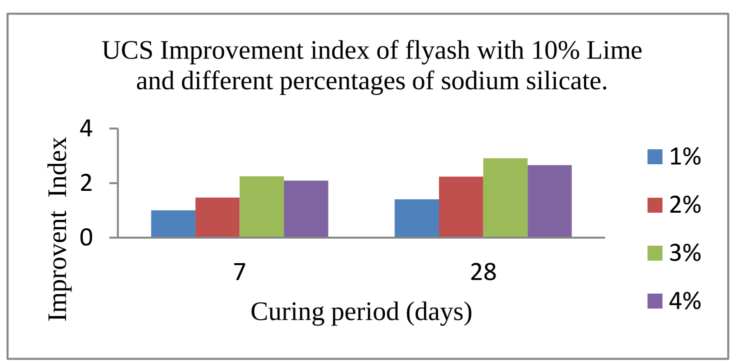
Sodium Silicate %	Curing period (days)			
	1	3	7	28
1	685	1065	1586	2224
2	1268	1856	2324	3548
3	1620	2442	3562	5016
4	1504	2042	3316	4612

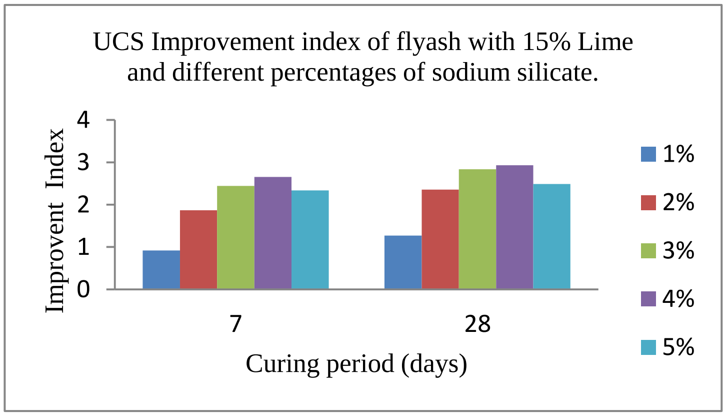
Unconfined Compressive strength for flyash, 12% lime and different percentages of sodium silicate (kPa):

Sodium silicate (%)	Curing period (days)			
	1	3	7	28
1	1086	1344	1582	2435
2	1524	2268	3423	4560
3	2312	3328	4642	5820
4	2291	3082	4234	5265
5	1825	2640	3572	4818

Unconfined Compressive strength for flyash, 15% lime and different percentages of sodium silicate (kPa):

Sodium silicate (%)	Curing period (days)			
	1	3	7	28
1	1254	1529	1892	2616
2	1629	2635	3842	4852
3	2624	3822	5026	5835
4	2834	4102	5464	6730
5	2416	3635	4811	5818





Water absorption for stabilized flyash with 10% lime and sodium silicate:

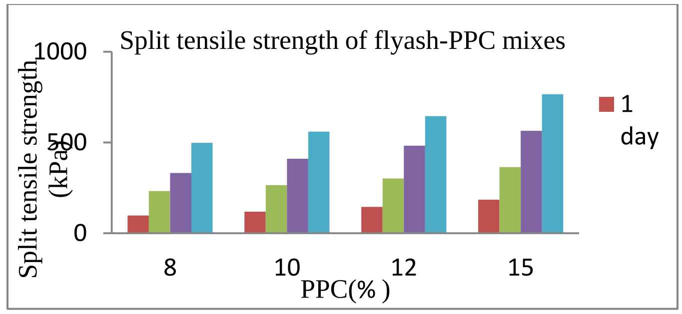
Sodium Silicate (%)	Curing period(days)	
	7	28
0	2.16	1.95
1	0.85	0.82
2	0.80	0.74
3	0.74	0.69
4	0.70	0.67

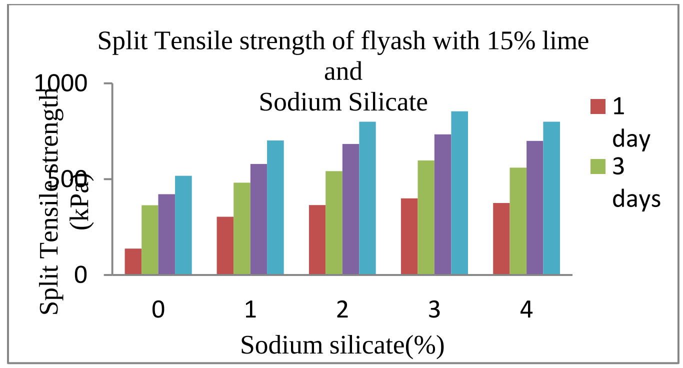
Water absorption for stabilized flyash with 15% lime and sodium silicate:

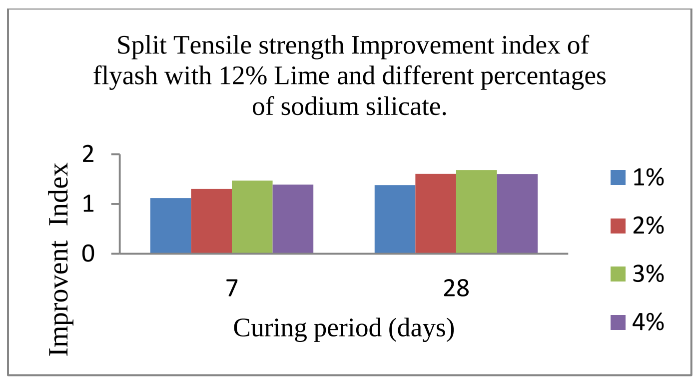
Sodium Silicate (%)	Curing period(days)	
	7	28
0	1.68	1.50
1	0.72	0.60
2	0.60	0.55
3	0.52	0.50
4	0.50	0.48
5	0.48	0.47

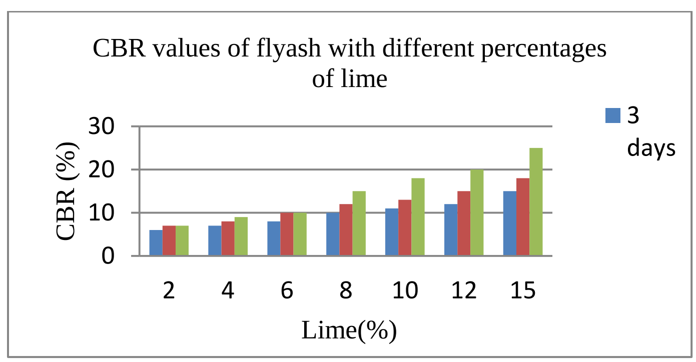
Split Tensile strength of flyash and lime mixes (kPa):

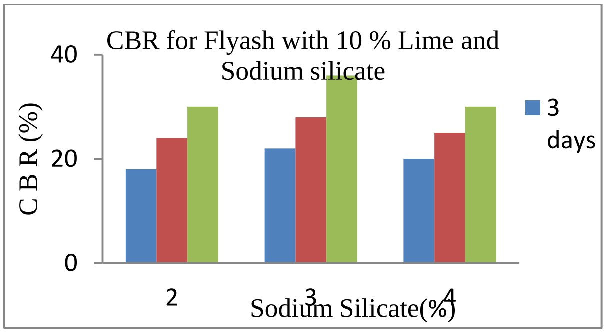
Lime (%)	Curing period (days)			
	1	3	7	28
8	88	181	256	342
10	104	212	306	406
12	121	289	376	452
15	138	364	422	518

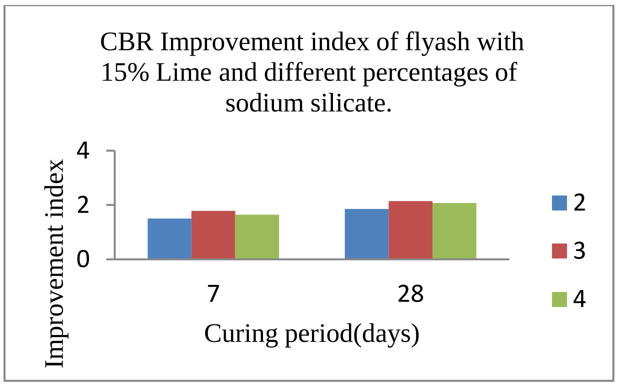












Improvement index of flyash for CBR with 10% Lime and different percentages of sodium silicate.

Sodium silicate (%)	Curing period (days)	
	7	28
2	1.6	2
3	1.86	2.4
4	1.66	2

Improvement index of flyash for CBR with 15% Lime and different percentages of sodium silicate.

Sodium silicate (%)	Curing period (days)	
	7	28
2	1.52	2
3	1.84	2.48
4	2	2.72

IV. CONCLUSION

From the study of flyash stabilized with lime, cement and sodium silicate at compacted condition. The following conclusions have derived:

- Addition of lime, cement and sodium silicate to flyash increases UCS, Split tensile strength and CBR values for all curing periods.
- These strengths also increase with increase in curing periods. Maximum increase was observed for 7 days and continued for 28 days.
- The flyash lime stabilized mixes have shown UCS value for 7 days is 80% of 28 days strength, in cement stabilized flyash it is 70% of 28 days strength. Whereas in flyash-lime-sodium silicate mixes 60-80% of 28 days.
- Flyash-lime-sodium silicate stabilized soils achieved 10% excess strength than the cement stabilized soils.
- Maximum strengths are due to development of pozzolanic reaction between silica alumina with calcium forming calcium silicate accumulate gel. These gels crystalline with time are responsible for development of maximum strengths.
- Agglomeration has taken place due to additives such as lime, cement and sodium silicate with time.
- 8-12% lime with 2-4% of sodium silicate can be comparable with 10-15% of cement in flyash stabilization.
- Addition of 6% cement, 6% lime and 8%lime with 1% Sodium silicate achieved CBR greater than 10 so that it can be used as sub grade material for road pavements.
- Addition of 2% cement, 8%lime with 2% Sodium silicate achieved CBR greater than 30 so that it can be used for sub base.
- Addition of 15% lime with 3% sodium silicate gives CBR greater than 60 it can be used as base course for pavements.

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