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Effect of curing periods and strength characteristics of lime and calcium tri-silicate stabilized flyash

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Abstract

Every year million tonns of flyash is produced all over india and its disposal is a big problem. For the bulk utilization of flyash in geotechnical constructional activities like roads, embankments etc , admixtures like lime and silicate were added to flyash and exposed for different curing periods and tested for unconfined compressive strength, split tensile strength. The experimental results show that high strength achieved at 7days and 28days curing period for 10 to 15% of lime and 2 to 5% of Calcium tri-silicate. It can be used for making of bricks, micro piles and also used for grouting techniques.

Keywords– flyash, Calcium tri silicate, unconfined compressive strength (UCS), split tensile strength.

1.Introduction

Flyash is an industrial product obtained by burning of coal. Flyash frequently used as construction material, this can also used in geotechnical construction purposes such as fill material, embankment material, road components etc. due to its pozzolonic nature and to obtain high strengths of flyash can be admixtured with lime and silicates etc. To avoid difficulties in stabilization techniques like mixing, placing, compaction etc. pouring of flyash with some admixtures at their pouring consistency may help in avoiding the above disturbancy.

Leonards and Baily (1982) studied the unconfined compressive strength are increasing with fineness of ash. Yudhbir and Hongo (1991) considered unconfined compressive strength of flyashes as a measure of self hardening properties of flyashes. They also explain free lime content of flyash contribute for self hardening property. Sherwood and Ryley (1966) and Raymond (1961) reported that the fraction of lime present as a free lime in the form of calcium tri oxide or calcium tri hydroxide controlls self hardening characteristics of flyashes. Singh (1996a) studied the unconfined compressive strength of flyashes increases with increase in lime content, higher lime content exhibits high strengths. Variation in unconfined compressive strengths of different flyashes on curing has been considered due to their difference in their free lime contents. It is also undestood that the strength gain with time is due to pozzolonic reaction between reactivity silica and free lime contents. Addition of lime to flyashes increases strength with curing. The development of strength also depends on the conditions that follow in stabilization. The strenth influenced by type and amount of lime, curing period etc (Ingels and metcalf 1972).

2.Material used

The materials used in this investigation are Flyash (NTPC), Lime and Calcium tri-silicate.

Flyash is collected from NTPC Paravada in Visakhapatnam 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. Chemical composition of Flyash is shown in table 2.

Property	Values
Gravel (%)	0
Sand (%)	28
Fines (%)	72
a. Silt(%)	72
b. Clay(%)	0
Liquid Limit (%)	24
Plastic Limit (%)	NP
Specific gravity	2.1
OMC (IS heavy Compaction)	
Optimum moisture content (%)	21.0
Maximum dry density (g/cc)	1.28
California bearing ratio	3

Table: 1

Compound	Formula	Percentage (%)
Magnesium oxide	MgO	0.86
Aluminum trioxide	Al2O3	30.48
Silica dioxide	SiO2	59.83
Calcium oxide	CaO	1.74
Titanium oxide	TiO2	6.91
Zinc oxide	ZnO	0.09

Table: 2

Lime: Chemical composition of laboratory hydrated lime is $Ca(OH)_2$, CaO is 90% pure.
Calcium tri-silicate: Chemical composition of laboratory Calcium tri-silicate is $CaSiO_3$.
Figures:

Fig 1

Fig 2

Fig 3

Fig 4

Fig 5

3. Experimental programme:

In this study dry flyash has been mixed with lime (5%, 10% and 15%) and Calcium tri-silicate (1, 2, 3, 4 and 5%) by percentage weight of dry flyash and added water of 30%, 35% and 40%

by their weight and thoroughly mixed to get the required consistency and poured these samples into given sizes(38mm X 76mm) of samplers and kept cured for 1 day, 3 days, 7 days and 28 days respectively by maintaining 100% humidity and without loss of moisture content from the samples.

4. Results and Discussions:

4.1 Unconfined Compressive Strength (kg/cm^2):

The samples of sizes 38 mm diameter and height of 76 mm were prepared as said above by free pouring in the UCS moulds. All the prepared samples were cured for 1 day, 3 days, 7 days and 28 days by maintaining 100% humidity. Unconfined compressive strength test were conducted after completion of their curing period at a strain rate of 1.25 mm/min.

Unconfined Compressive strength of flyash with 5% lime and calcium tri silicate (free pouring consistency):

Curing period	Water content	Calcium tri silicate %					
		1	2	3	4	5	6
1	30	0.52	0.74	0.79	0.86	1.02	-
	35	0.49	0.72	0.76	0.84	0.97	1.1
	40	0.48	0.69	0.73	0.83	0.91	1.03
3	30	0.72	1.88	1.82	1.7	1.4	-
	35	1.02	1.89	2.64	3	2.64	2.48
	40	3.65	5	8.12	6.8	6.45	6.2
7	30	2.16	4.02	3.1	2.72	2.48	-
	35	2.82	3.4	5.12	4.68	3.86	-
	40	4.8	8.21	13.25	12.1	11.6	11
28	30	3.02	5	8.12	7.65	7.06	-
	35	5.26	8.11	9.75	8.6	8	-
	40	7.69	10.8	17.1	16.2	15.28	-

Table: 3

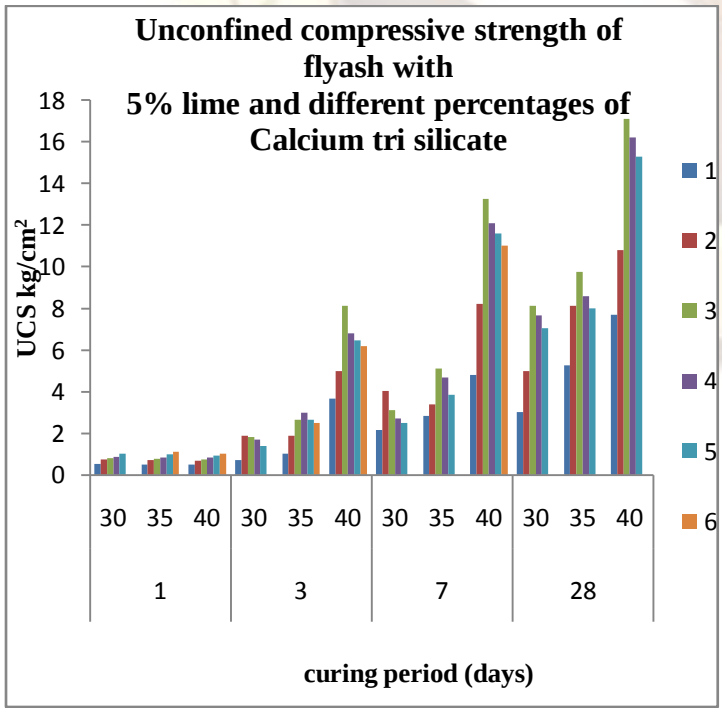

Fig: 1

For 5% lime, at different percentage of water content 3% calcium tri-silicate gives good strength of flyash at all curing periods and the maximum strength observed at 40% water content and 28 days curing period is 17.1kg/cm^2.

Unconfined Compressive strength of flyash with 10% lime and calcium tri silicate (free pouring consistency):

Curing period	Water content	Calcium tri silicate %					
		1	2	3	4	5	6
1	30	1.18	1.34	1.82	2.36	2.12	1.88
	35	1.02	1.52	1.89	2.65	2.42	2.11
	40	1.22	1.82	2.2	2.86	2.42	2.16
3	30	2.31	3.82	5.89	6.45	5.32	4.85
	35	3.82	5.88	7.65	10.02	8.65	7.52
	40	6.1	9.2	12.68	14.9	13.52	13
7	30	5.45	8.42	10	11.62	10.88	10.62
	35	8.08	11.85	13.9	14.65	13.8	12.89
	40	10.92	15.1	17.2	20.5	18.6	18.1
28	30	8.04	14.02	16	20.24	18.62	17.2
	35	10.3	14	16.58	20.32	18.05	17.26
	40	14.25	20.3	25.78	28.65	27.3	26

Table: 4

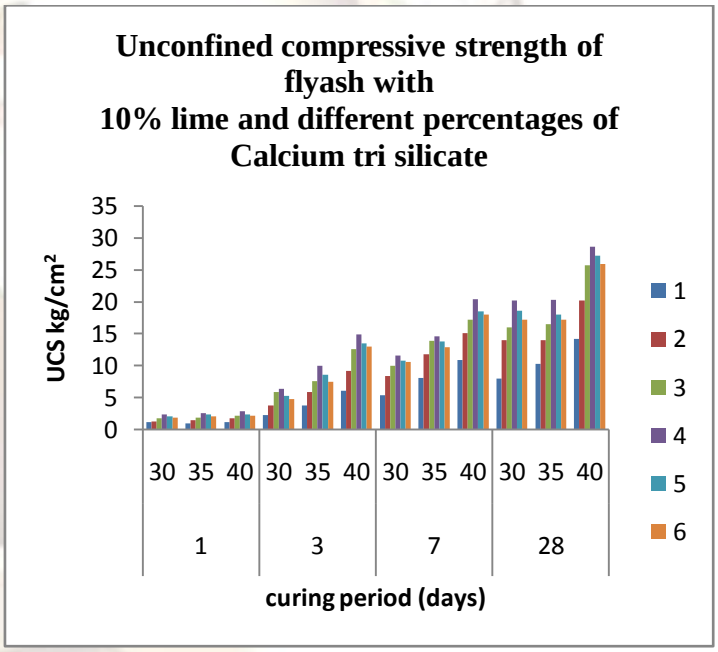

Fig: 2

For 10% lime, at different percentage of water content 4% calcium tri-silicate gives good strength of flyash at all curing periods and the maximum strength observed at 40% water content and 28 days curing period is 28.65kg/cm^2.

Unconfined Compressive strength of flyash with 15% lime and calcium tri silicate (free pouring consistency):

Curing period	Water content	Calcium tri silicate %					
		1	2	3	4	5	6
1	30	1.26	1.52	1.9	2.02	2.06	2.02
	35	1.62	2	2.28	2.36	2.68	2.24
	40	1.76	2.2	2.68	3	3.56	3.02
3	30	2.48	5.1	7.02	7.68	8.04	7.48
	35	4.32	7.1	8.88	11.02	12.12	10.68
	40	7.16	13.82	16.35	19.22	22	20.1
7	30	6.35	9.54	11.88	13.66	15.72	14.4
	35	9	12.89	15.42	16.28	17	16.65
	40	12.12	17.2	20.95	22.8	23.6	21.8
28	30	9.68	15.72	19.65	22.21	24.11	22.32
	35	10.4	17.09	21.2	23.4	25.1	24
	40	16.54	22.6	28.1	30.95	33.1	30.2

Table: 5

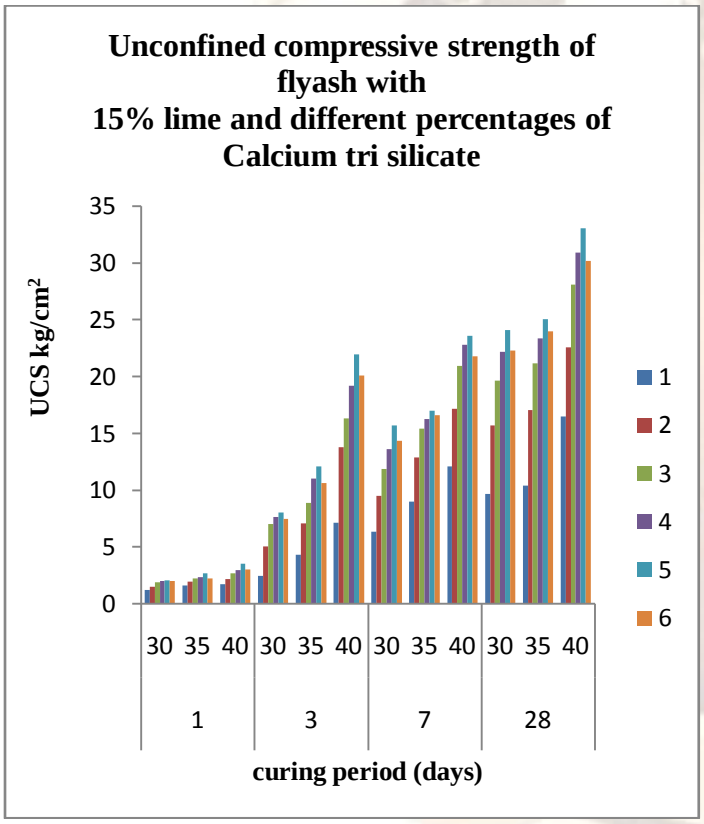

Fig: 3

For 15% lime, at different percentage of water content 5% calcium tri-silicate gives good strength of flyash at all curing periods and the maximum strength observed at 40% water content and 28 days curing period is 33.1kg/cm^2.

4.2 Split Tensile Strength (kPa):

The samples of sizes 38 mm diameter and height of 76 mm were prepared by static compaction method to achieve maximum dry density at their optimum moisture contents OMC. All the prepared samples were cured for 1 day, 3days, 7 days and 28 days by maintaining 100% humidity. The sample is loaded until splitting / failure load takes after completion of their curing period at a strain rate of 1.25 mm/min.

Tensile strength, $S_t = 2P_u/ \pi Dt$

Where, P_u = ultimate load at which failure of sample.

D = diameter of specimen, mm

t = length of specimen, mm

Split tensile strength of flyash with 5% lime and calcium tri silicate (free pouring consistency):

Curing period	Water content	Calcium tri silicate %				
		2	3	4	5	6
3	30	0.24	0.22	0.2	0.18	0.16
	35	0.22	0.33	0.39	0.37	0.33
	40	0.64	0.98	0.86	0.78	0.72
7	30	0.55	0.44	0.39	0.36	0.32
	35	0.46	0.71	0.66	0.53	0.46
	40	1.28	1.96	1.8	1.69	1.63
28	30	0.71	1.5	1.11	1.06	0.96
	35	1.15	1.4	1.26	1.21	1.19
	40	1.6	2.51	2.38	2.12	2.09

Table: 6

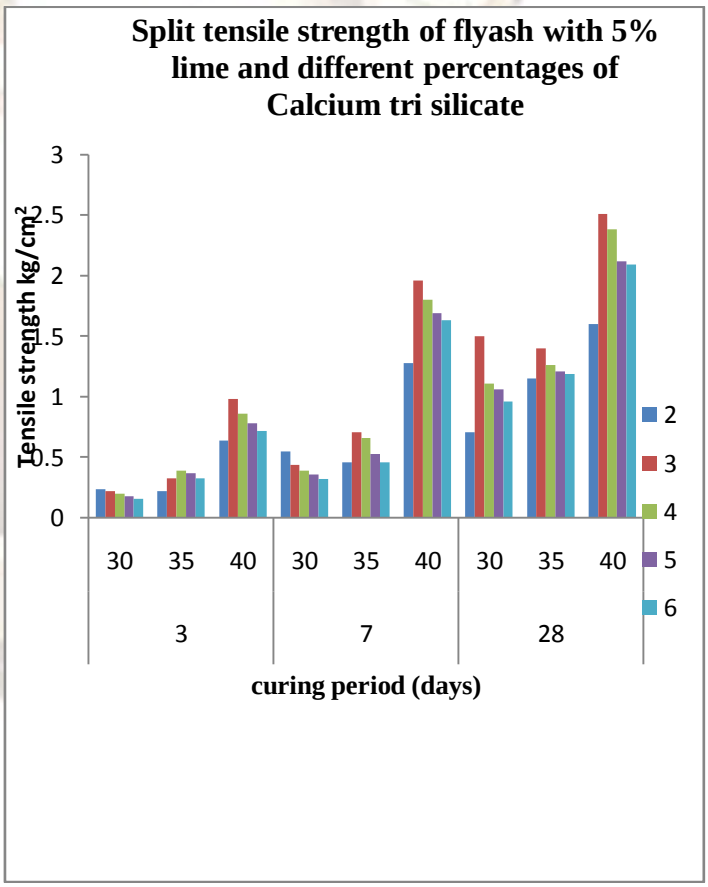

Fig: 4

For 5% lime, at different percentage of water content 3% calcium tri-silicate gives good strength of flyash at all curing periods and the

maximum strength observed at 40% water content and 28 days curing period is 2.51kg/cm^2.

Split tensile strength of flyash with 10% lime and calcium tri silicate (free pouring consistency):

Curing period	Water content	Calcium tri silicate %				
		2	3	4	5	6
3	30	0.48	0.74	0.78	0.75	0.7
	35	0.71	0.93	1.25	1.21	1.19
	40	1.2	1.6	1.9	1.86	1.83
7	30	1.19	1.4	1.64	1.59	1.54
	35	1.67	1.95	2	1.94	1.91
	40	2.12	2.4	2.66	2.54	2.49
28	30	2.04	2.35	2.85	2.69	2.64
	35	2	2.41	2.9	2.85	2.82
	40	2.92	3.78	4.1	3.96	3.94

Table: 7

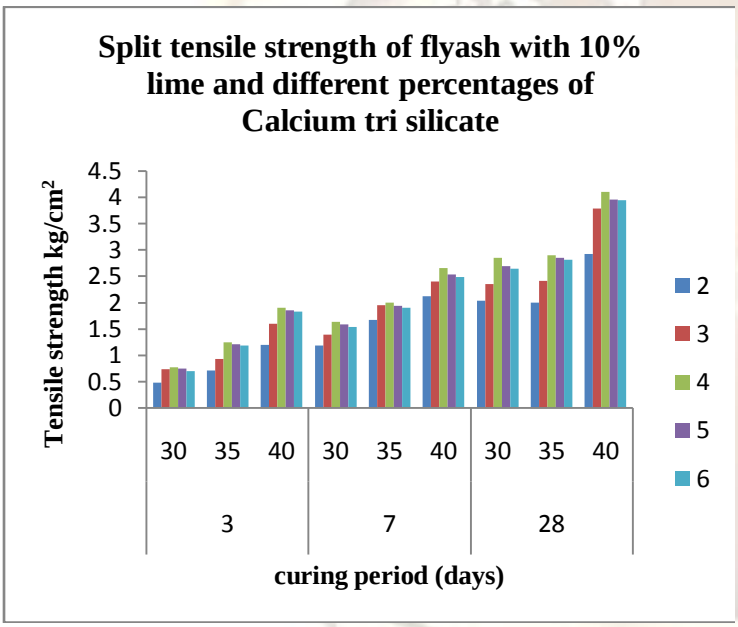

Fig: 5

For 10% lime, at different percentage of water content 4% calcium tri-silicate gives good strength of flyash at all curing periods and the maximum strength observed at 40% water content and 28 days curing period is 4.1kg/cm^2.

Split tensile strength of flyash with 15% lime and calcium tri silicate (free pouring consistency):

Curing period	Water content	Calcium tri silicate %				
		2	3	4	5	6
3	30	0.63	0.89	0.93	1.04	1.02
	35	0.88	1.14	1.4	1.8	1.73
	40	1.66	2.05	2.45	2.89	2.85
7	30	1.35	1.65	1.96	2.09	2.03
	35	1.8	2.15	2.3	2.48	2.41
	40	2.5	3	3.3	3.74	3.69
28	30	2.28	2.75	3.24	3.48	3.42
	35	2.4	3.08	3.35	3.9	3.84
	40	3.25	4.09	4.35	4.64	4.61

Table: 8

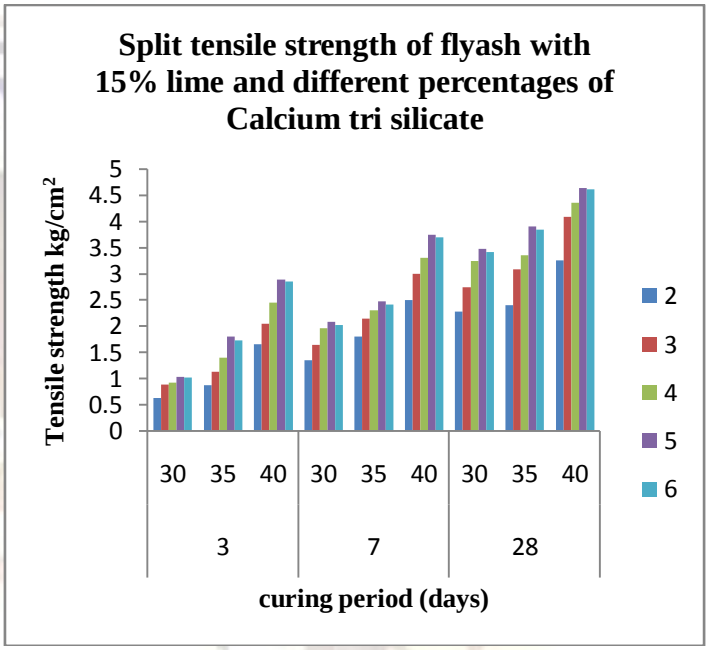

Fig: 6

For 15% lime, at different percentage of water content 5% calcium tri-silicate gives good strength of flyash at all curing periods and the maximum strength observed at 40% water content and 28 days curing period is 4.64 kg/cm^2.

5. Conclusions:

- When lime and calcium tri-silicate percentages are increasing the strength values are also increasing.
- For higher percentage of lime more amount of calcium tri-silicate is required to attain more strength.
- For high percentages of lime and calcium tri-silicate the requirement of water is more to get better strength values.
- At increasing percentages of lime and calcium tri-silicate the strength increases up to some percentage and by further increase in lime and silicates the decreasing trend of strengths are observed.

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