"EXPERIMENTAL STUDY ON CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT WITH LIME AND FLY ASH"

A PROJECT REPORT

Submitted in partial fulfillment of the requirements for the award of the degree

of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision of

Prof. (Dr.) Ashok Kumar Gupta

(Head of the Department)

By

Abhishek Saini (121432)

to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT, SOLAN – 173 234

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CERTIFICATE

This is to certify that the work which is being presented in the project title **" EXPERIMENTAL STUDY ON CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT WITH LIME AND FLY ASH"** in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology submitted in Civil Engineering Department, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by **Tarun Gaur & Rishab Attri** during a period from August 2016 to May 2017 under the supervision of (Prof.)Dr. **Ashok Kumar Gupta**, Head of the Department Civil Engineering Department, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of my knowledge.

Date: 7/5/17

Dr. Ashok Kumar Gupta

Professor & Head of Department
Civil Engineering Department,
JUIT Waknaghat

8/5/17

External Examiner

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TABLE OF CONTENT

1. INTRODUCTION

The most popular artificial material on Earth isn't steel, plastic, or aluminum — it's concrete. Thousands of years ago, we used it to build civilizations, but then our knowledge of how to make it was lost. Here's how we discovered concrete, forgot it, and then finally cracked the mystery of what makes it so strong. Basically, concrete is just a bunch of rubble mixed with water and cement. Together, these ingredients form rocky jello that can be poured into a mold and shaped into whatever the heck you like. Today many admixtures have been introduced to enhance the properties of concrete. Use of fly ash and lime as the replacement of cement in concrete mix is considered very eco-friendly and it is also economical. It saves the cement requirement for the same strength thus saving of raw materials such as limestone, coal etc required for manufacture of cement. Fly ash is pozzolanic material & it improving the properties of concrete like compressive strength & Durability. This project presents the experimental investigation carried out to evaluate the effect of partial replacement of cement with fly ash which is waste product generated from the industries. Numerous tests are performed on wet concrete such as workability tests such as compaction factor test and slump test. The tests on hardened concrete are destructive test while the destructive test includes compressive test on concrete cube for size (150 x 150 x 150) mm, Flexural strength on concrete beam (500 x 100 x100) and split tensile strength on concrete cylinder (150 mm ø x 300mm) as per IS: 516 – 1959, IS: 5816 – 1999 and IS: 516 – 1959 respectively Several researchers in the past investigated the effect of mineral and chemical admixtures on the properties of the concrete adopting different theories

P. R. Wankhede, V. A. Fulari investigated that the experimental study on partial replacement of cement by Fly ash. This research concludes the study on ―the effect of fly ash on the properties of concrete‖ for nominal mix of M25 grade of concrete are as follows.

1. Slump loss of concrete increases with increase in w/c ratio of concrete.
2. For w/c ratio 0.35 without any admixtures, initial slump cannot be measured by slump cone test as it is

Very less.

3. Ultimate compressive strength of concrete goes on decreasing with increase in w/c ratio of concrete.

4. Slump loss of concrete goes on increasing with increase of quantity of fly ash.

5. Concrete with 10% and 20% replacement of cement with fly ash shows good compressive strength for 28 days than normal concrete for 0.35 w/c ratio.

6. But in the case of 30% replacement of cement with fly ash ultimate compressive strength of concrete decreases.

S. H. Sathawane, A.R. Narde investigated that the experimental study on Effect of Partial Replacement of Cement by Fly Ash, Rice Husk Ash with Using Steel Fiber in ConcreteR. S. Deotale, This research concludes that –

1 Compressive strength increases with the increase in the percentage of Fly ash and Rice Husk Ash up to replacement (22.5%FA and 7.5% RHA) of Cement in Concrete for different mix proportions.

2 The maximum 28 days split tensile strength was obtained with 22.5% fly ash 7.5% rice husk ash mix.

3 The maximum 28 days flexural strength was obtained again with 22.5% fly ash and 7.5% rice husk ash mix.

4 The percentage of water cement ratio is reliant on quantity of RHA used in concrete. Because RHA is a highly porous material

5 The workability of concrete had been found to be decrease with increase RHA in concrete.

2 SCOPES AND OBJECTIVE

The objectives and scope of present study are.

 To find the optimum mix design with regards to the amount of water, lime, Flyash and cement ratio.

 To investigate the physical properties of the lime and FA strength (bending and compression)

 To study the relative strength development with age of (lime + FA) concrete with control concrete.

 Use of industrial waste in a useful manner.

 To conduct compression test on (lime+FA) and control concrete on standard IS specimen size (150 x 150 x 150) mm.

 To conduct Flexural test on (lime+FA) and control concrete on standard IS specimen size (100 x 100 x 500) mm.

 To conduct split tensile test on (lime+FA) and control concrete on standard IS specimen size (100 mm ø x 300mm) mm.

 Toprovide economical construction material.

 Provide safeguard to the environment by utilizing

3 MATERIAL PROPERTIES

3.0 Cement

Ordinary Portland Cement of 43 grade manufactured by the JP Cement Company confirming to IS 8112:1989 is used in this study. The Properties of Cement are shown in Table 1

Table 1: Physical properties of cement

S.No.	Test	Result	Specified by IS 8112:2013
1	Fineness of cement (kg/m^2)	245	225
2	Consistency of cement	36	30
3	Initial setting time (minutes)	75	30
4	Final setting time (minutes)	260	600
5	Specific gravity	3.12	2.5-3.5
6	Compressive strength (N/mm^2)	48.3	58
7	Soundness (mm)	3	10

3.1 Fine aggregate

Fine aggregate is used after sieving sand which passed through 4.75mm IS sieve

3.2 Coarse aggregate

The Coarse aggregate are obtained from a local quarry. The coarse aggregate is used with maximum size of 12mm

3.3 Fly ash

Fly ash is obtained in the process of combustion of coal. Nowadays, fly ash is commonly used as replacement (partial) for Portland cement in order to obtain concrete of higher strength and durability because fly ash reacts with the lime present in Portland cement to form a more durable binder. Class F fly ash is used. It was grey in color, particle size less than 35µm. Its specific gravity is 2.24.

Table 2: Physical properties of fly ash

S.No.	Parameters	Fly Ash
1	Bulk Density (gm/cc)	0.9-1.3
2	Specific Gravity	1.6-2.6
3	Plasticity	Lower or non-plastic
4	Shrinkage Limit	Higher
5	Clay	Negligible
6	Free Swell Index	Very low
7	Classification (Texture)	Sandy silt to silty loam
8	Water Holding Capacity	40%-60%
9	Porosity	30%-65%

Table 3: Chemical properties of fly ash

S.No.	Compounds (%)	Fly Ash
1	SiO_2	38-63
2	$Al_2 O_3$	27-44
3	TiO_2	0.4-1.8
4	$Fe_2 O_3$	3.3-6.4
5	MgO	0.01-0.5
6	CaO	0.2-8
7	$K_2 O$	0.04-0.9
8	$Na_2 O$	0.07-0.43
9	LOI	0.2-5.0
	pH	6-8

3.4 LIME

The white powdered slaked lime has a wide range of applications in construction. The properties of lime are:

1. **Cementing capability**– This is obtained by their carbonation with carbon dioxide. Lime is used as lime mortar for brick masonry construction.
2. Have a **higher acid resistance**– due to its alkaline nature
3. Gain **Pozzolanic activity**– this gives cementitious products
4. **Sealing of micro cracks**– This is done by the precipitation made by the calcium carbonate when carbon dioxide passes through the lime mortar mix.

The table below shows the physical and chemical properties of lime under various classes as per IS:4031-1968 and IS:6932-1972 Part (3 to 10)

Table 4. As per IS 6932-1973 (Part 1 to 11, RA 2009), Building Lime Physical Requirements

Characteristic of lime	Class and type of building lime										Test method or test reference
	A	B		C		D		E	F		
	Hyd	Quick	Hyd	Quick	Hyd	Quick	Hyd	Hyd	Quick	Hyd	
1 Fineness											
(a) residue on 2.36 mm IS sieve, %, max	Nil	-	Nil	-	Nil	-	Nil	Nil	-	Nil	
(b) residue on 300 micron IS sieve, %, max	5	-	5	-	Nil	-	Nil	5	-	5	IS 6932-1973 (part 4)
(c) residue on 212 micron IS sieve, %, max	-	-	-	-	10	-	10	-	-	-	
2 Residue on slaking											
(a) residue on 850 micron IS sieve, %, max	-	10	-	5	-	5	-	-	10	-	
(b) residue on 300 micron IS sieve, %, max	-	-	-	5	-	5	-	-	-	-	IS 6932-1973 (part 3)
3 Setting time											
(a) Initial set, min, hour	2	-	-	-	-	-	-	2	-	-	
(b)) Final set, min, hour	48	-	-	-	-	-	-	48	-	-	IS 6932-1983 (part 11)
4 Compressive strength, min MPa											
(a) At 14 days	1.75	1.25	1.25	-	-	-	-	1	1.25	1.25	IS 6932-1973
(b) At 28 days	2.8	1.75	1.75	-	-	-	-	1.75	1.75	1.75	(part 7)
5 transverse strength, min, MPa											
(a) At 28 days	1	0.7	0.7	-	-	-	-	0.7	0.7	0.7	
6 Workability bumps, max	-	-	-	12	10	12	10	-	-	-	IS 6932-1973 (part 8)
7 Soundness	free	-	free	-	free	-	free	-	-	free	IS 6932-1973 (part 8)

4 Experimental Methodology

A total of four samples were designed for this study to investigate the effects of replacing cement with fly ash and lime on concrete for the experiment cement is replaced by 5% of lime & 5% of fly ash for first sample, 10% of fly ash & 15% of lime for second sample and 15% of fly ash & 10% of lime for third sample for M25 grade of concrete. The test moulds are kept ready before preparing the mix. Tighten the bolts of the moulds carefully because if bolts of the moulds are not kept tight the concrete slurry coming out of the mould when vibration takes place. Then moulds are cleaned and oiled on all contact surfaces of the moulds and place the moulds on vibrating table. The concrete is filled into moulds in layers and then vibrated. The top surface of concrete is struck off level with a trowel. The number and date of casting are put on the top surface of the cubes, cylinders and moulds. In this research work total 12 cubes (150*mm* X 150*mm* X150*mm*), 12 beam *(500mm X 100mmX 100mm)* and 12 cylinders (150*mm* X 300*mm*) are developed and results are analyzed after curing of 7, 14 and 28 days of concrete. The Data obtained from the replacement of fly ash and lime is compared with data obtained from a Conventional concrete.

5. Experimental Programme and Results

A mix M25 grade is designed and the same is used to prepare the test samples. The concrete mix proportion (cement: fine aggregate: coarse aggregate) is 1: 1: 2 by volume and a water-cement ratio of 0.35 is used. Designed mix is prepared for the conventional concrete. The details of replacement of fly ash and lime by cement are shown in Table 5.

Table 5: Replacement of fly ash and lime (by weight)

Sample no.	cement	Fly ash	lime	Fine aggregate	Course aggregate
1	0.1	0	0	0.1	0.1
2	0.90	0.5	0.5	0.1	0.1
3	0.75	0.10	0.15	0.1	0.1
4	0.75	0.15	0.10	0.1	0.1

5.1 Compressive strength

Compression testing machine is used for testing the compressive strength of concrete. The samples of concrete mixed with fly ash and lime with different proportion are tested after curing of 7, 14 and 28 days. The results obtained from the experiment are shown in Table 6.

Out of many test applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. For cube test two types of specimens either cubes of (15cm X 15cm X 15cm) or (10cm X 10cm x 10cm) depending upon the size of aggregate are used. For most of the works cubical moulds of size 15cm x 15cm x 15cm are commonly used. This concrete is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of these specimen should be made even and smooth. These specimen are tested by compression testing machine after 7 , 14 and 28 days. Load should be applied gradually at the rate of 140 kg/cm^2

Compressive strength = load/area of cube

Table 6 Compressive Strength Results

Specimens	Cement	Fly ash	lime	Compressive strength at 7 days(N/mm^2)	Compressive strength at 14 days(N/mm^2)	Compressive strength at 28 days(N/mm^2)
Conventional concrete	0.1	0	0	25.04	28.74	33.33
5% fly ash & 5% lime	0.90	0.5	0.5	39.85	35.9	32.14
10% fly ash & 15% lime	0.75	0.10	0.15	26.32	31.28	38.19
15% fly ash & 10% lime	0.75	0.15	0.10	29.09	30.35	36.26

5.2 Split tensile strength

Compression testing machine is used for testing the split tensile strength of concrete. The samples of concrete mixed with fly ash and lime with different proportion are tested after curing of 7, 14 and 28 days. The results obtained from the experiment are shown in Table 7.

Tensile strength is an important property of concrete because structure are highly vulnerable to tensile cracking due to various kind of effects and applied loading itself. However , tensile strength of concrete is very low in compared to its compressive strength.

It is standard test cylinder of concrete specimen (300mm X 150mm diameter) is placed horizontally between the loading surfaces of compression testing machine. The compression load is applied diametrically and uniformly along the length of cylinder until the failure of cylinder along the vertical diameter. To allow the uniform distribution of this applied load and to reduce the magnitude of high compressive stresses near the point of application of this load, strips of plywood are placed between the specimen and loading platens of testing machine. Concrete

cylinder splits into two halves along this vertical plane due to indirect tensile stress generated by poisson's effect.

Due to compressive loading, an element lying along the vertical diameter of the cylinder is subjected to vertical compressive stress and a horizontal stress. The loading condition produces a high compressive stress immediately below the loading points. It is estimated that the compressive stress is acting 1/6 depth and the remaining 5/6 depth is subjected to tension due to Poisson's effect.

$$\mathbf{Tsp = (2P/ (\pi dL))}$$

Where,
P= maximum load
L= length of the specimen
d= diameter of width of the

Table 7 Split tensile Strength Results

Specimens	**Cement**	**Fly ash**	**lime**	**Split tensile strength at 7 days(N/mm^2)**	**Split tensile strength at 14 days(N/mm^2)**	**Split tensile strength at 28 days(N/mm^2)**
Conventional concrete	0.1	0	0	2.310	2.68	3.39
5% fly ash & 5% lime	0.90	0.5	0.5	2.72	2.57	3.06
10% fly ash & 15% lime	0.75	0.10	0.15	2.40	2.65	2.86
15% fly ash & 10% lime	0.75	0.15	0.10	2.49	2.00	3.24

5.3 Flexural strength

Flexural testing machine is used for testing the flexural strength of concrete. The samples of concrete mixed with fly ash and lime with different proportion are tested after curing of 7, 14 and 28 days. The results obtained from the experiment are shown in Table 8.

After splitting tensile test another common test performed for determination of tensile strength is the flexure test.

The test could be performed in accordance with as per BS 1881: Part 118: 1983. A simple plain concrete beam is loaded at one-third span points. Span of the beam is three times of its depth. For this test the beams of dimension 100mmX100mmX500mm were casted.

$$F_{bt} = PL / bd^2$$

Where,

b= width in cm of specimen

d= depth in cm of specimen at point of failure

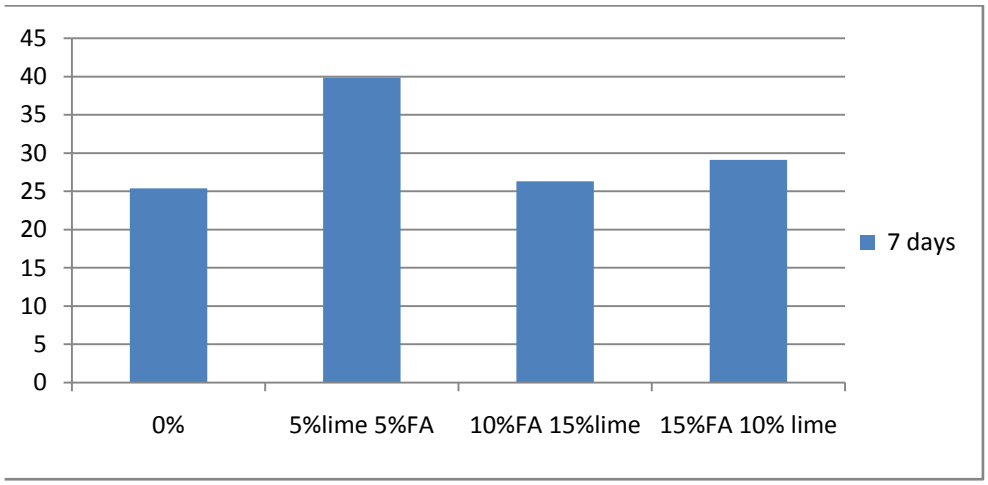
L= length in cm of specimen on which specimen was supported

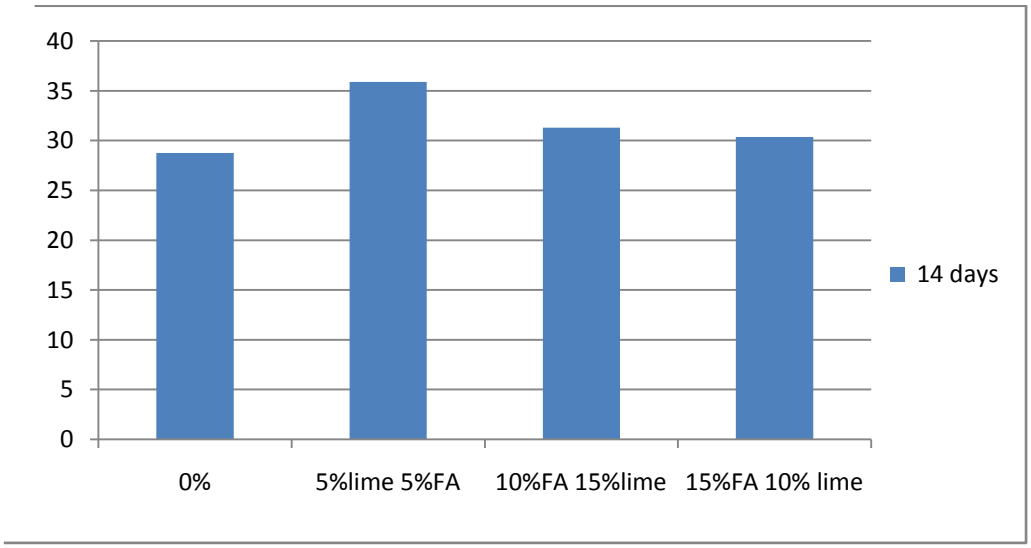
Table 8 Flexural Strength Results

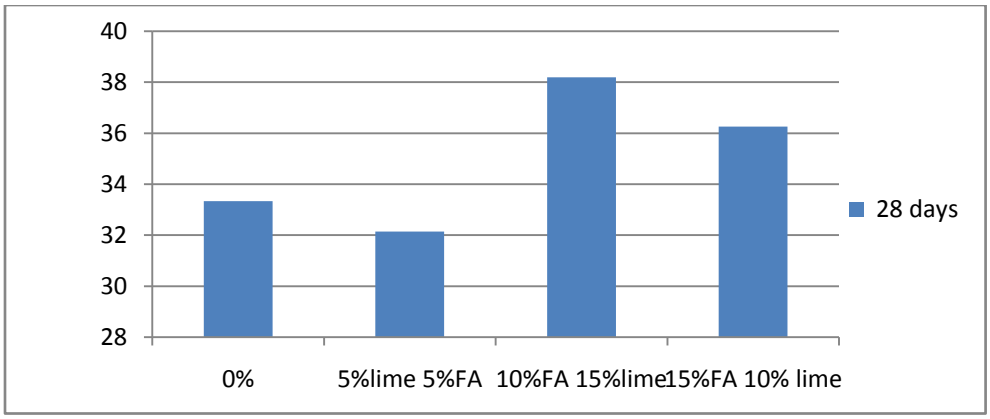
Specimens	Cement	Fly ash	lime	Flexural strength at 7 days(N/mm^2)	Flexural strength at 14 days(N/mm^2)	Flexural strength at 28 days(N/mm^2)
Conventional concrete	0.1	0	0	7.1	7.67	8.67
5% fly ash & 5% lime	0.90	0.5	0.5	5.1	7.8	10.5
10% fly ash & 15% lime	0.75	0.10	0.15	7.5	8.1	9
15% fly ash & 10% lime	0.75	0.15	0.10	8.1	8.2	8.2

6. Comparison and Discussion

1. Compressive strength v/s fly ash and lime replacement



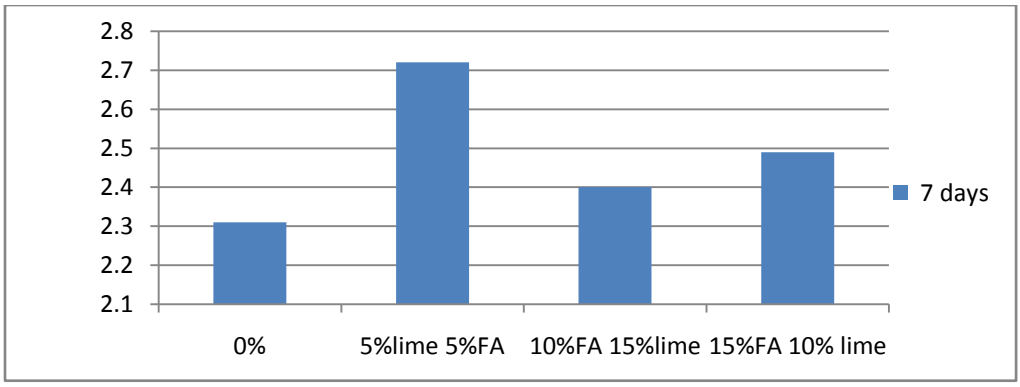




Compressive strength (N/mm^2)

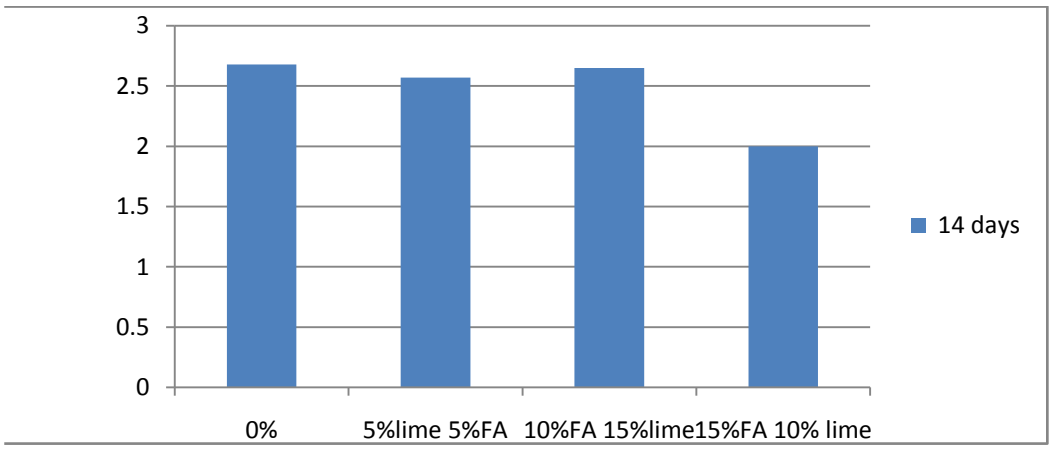
% lime & FA replacement

2. Split tensile strength v/s fly ash and lime replacement



Split tensile strength (N/mm^2)

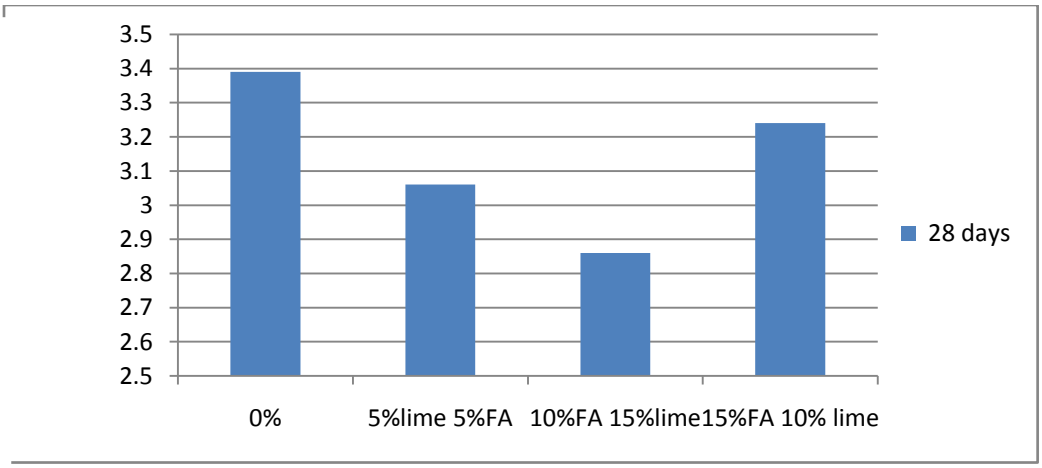
% lime & FA replacement



Split tensile strength (N/mm^2)

% lime & FA replacement

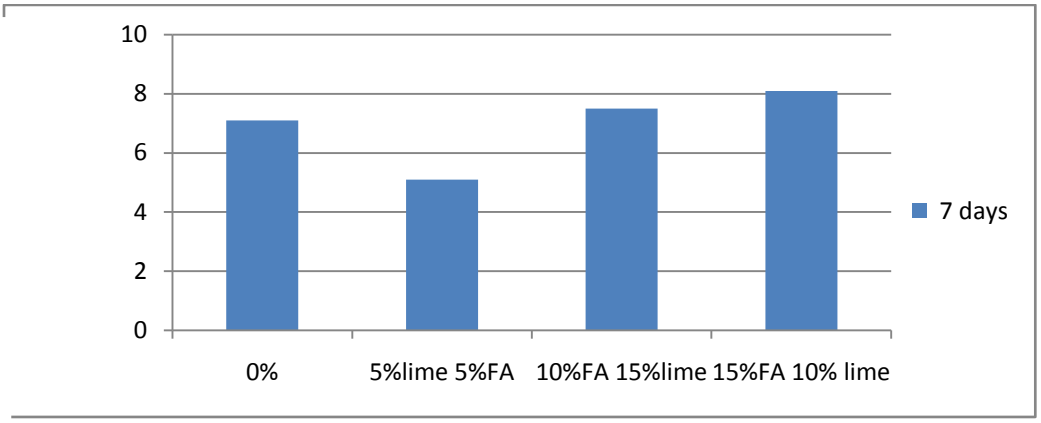
Split tensile strength (N/mm^2)



% lime & FA replacement

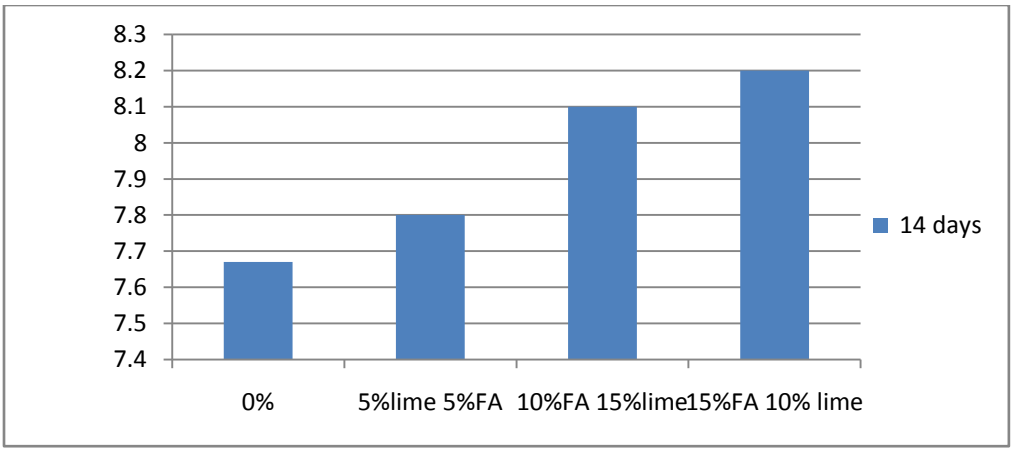
2. Flexural strength v/s fly ash and lime replacement

Flexural strength (N/mm^2)



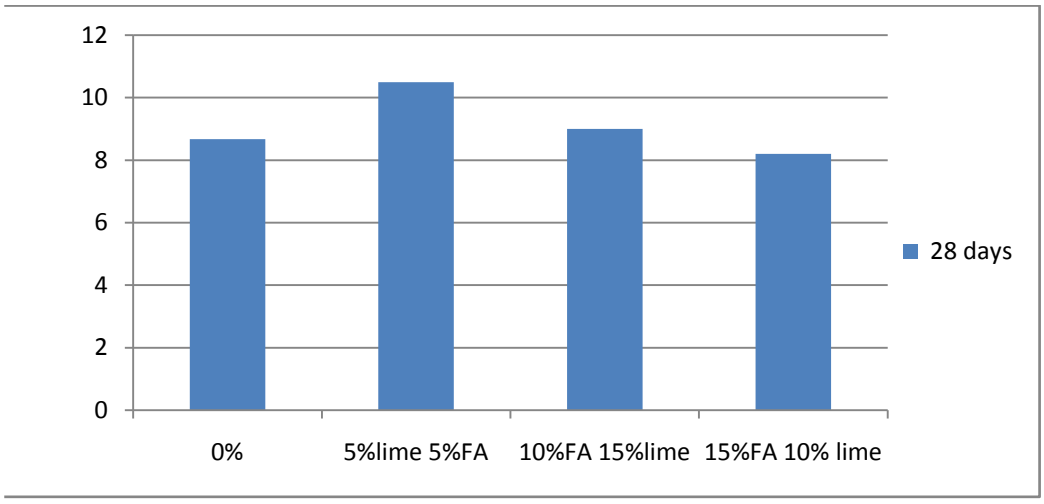
% lime & FA replacement

Flexural strength (N/mm^2)



% lime & FA replacement

Flexural strength (N/mm^2)



% lime & FA replacement

7 Conclusions

1. Compressive strength of concrete is seemed to be increased by replacement of cement with fly ash and lime at diff %age. There is slightly decrease in compressive strength for 5% lime and fly ash each at 28 days than conventional concrete mix.

2. For the age of 7 days split tensile strength decreases by small value than conventional concrete.

3. Flexural strength of concrete increases with replacement of cement with fly ash and lime at different %age than conventional concrete.

4. As the percentage of fly ash increases and lime decreases flexural strength increases.

8 BENEFITS AND LIMITATIONS

8.1 Benefits

The advantage of using fly ash in concrete includes the followings.

- Fly ash in the concrete mix efficiently replaces Portland cement that in turn can aid in making big savings in concrete material prices.
- It is also an environmentally-friendly solution, which meets the performance specifications. It can also contribute to LEED points.
- It improves the strength over time and thus, it offers greater strength to the building.
- Increased density and also the long-term strengthening action of flash that ties up with free lime and thus, results in lower bleed channels and also decreases the permeability.
- The reduced permeability of concrete by using fly ash, also aids to keep aggressive composites on the surface where the damaging action is reduced. It is also highly resistant to attack by mild acid, water and sulfate.
- It effectively combines with alkalis from cement, which thereby prevents the destructive expansion.
- It is also helpful in reducing the heat of hydration. The pozzolanic reaction in between lime and fly ash will significantly generate less heat and thus, prevents thermal cracking.
- It chemically and effectively binds salts and free lime, which can create efflorescence. The lower permeability of fly ash concrete can efficiently reduce the effects of efflorescence.

8.2 Limitations

There are also some disadvantages of using fly ash that should be considered.

- The quality of fly ash to be utilized is very vital. Poor quality often has a negative impact on the concrete.
- The poor quality can increase the permeability and thus damaging the building.
- Some fly ash, those are produced in power plant is usually compatible with concrete, while some other needs to be beneficiated, and few other types cannot actually be improved for using in concrete. Thus, it is very much vital to use only high quality fly ash to prevent negative effects on the structure of the building.

The aforesaid is few advantages and disadvantages of fly ash concrete. This type of concrete offers many advantages and as mentioned above it also has some disadvantages. There are various other advantages of utilizing fly ash concrete such as it is much easier to place with reduced effort and it is also able to have improved finishing to the structure with such type of concrete. Fly ash concrete can certainly add greater strength to the building.

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