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An Experimental Investigation on Properties of Concrete by Using Activated Flyash

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***Abstract*—** *Cement concrete is the most widely used construction material in any infrastructure development projects. The production of Portland cement, an essential constituent of concrete, release large amount of CO2 into the atmosphere.CO2 is major contributor to the green house effect and the global warming of the planet, which is a major global environmental issue currently the planet is encountering. The development and use of mineral admixture for cement replacement is growing in construction industry mainly due to the consideration of cost saving, energy saving, environmental production and conservation of resources. Mineral admixtures generally used are raw fly ash, rice husk ash, metakaolin, silica fume etc. Addition of such materials improves the concrete property. The fly ash is among the commonly used mineral admixtures as it is available in large quantities in many developing countries. The blending materials like fly ash and rice husk are already used without activation and their physical and chemical properties are studied by many authors. The performance of fly ash concrete can be improved by many means. The methods like chemical activation, mechanical and thermal activation are in practice. The objective of the present investigation is to improve the quality of fly ash by chemical treatment and to study the flexural behavior of reinforced cement concrete beams. For this project work the chemicals like sodium silicate, calcium oxide are used to activate the fly ash. In this study the material properties of activated fly ash like compressive strength, tensile strength, and flexural strength are studied with various replacements with cement like 10%, 20%, 30%, 40%, 50%, and 60%.The results are compared with fly ash concrete and control mix..*

***Keywords*—** *Activated fly ash, calcium oxide sodium silicate*.

I. INTRODUCTION

Concrete, is most widely used man made construction material and is the largest production of all the materials used in construction industry. Concrete is basically made of cementitious materials which have to properly bind themselves together, as well as with other materials to form a solid mass. Concrete or mortar is made up of cement, water and aggregates (Coarse and Fine Aggregate) and sometimes with necessary admixtures. Concrete has attained the status of a major building material in all the branches of modern construction. It is difficult to point out another material of construction which is as variable as concrete. Concrete is the best material of choice where strength, durability, impermeability, fire resistance and absorption resistance are required. Compressive strength is considered as an index to assess the overall quality of concrete and it is generally assumed that an improvement in the compressive strength results in improvement of all other properties. Hence strength investigations are generally centered on compressive strength. Even though concrete mixes are proportioned on the basis of achieving the desired compressive strength at the specified age, flexural strength often play a vital role in concrete making. Energy plays a crucial role in growth of developing countries like India. In the context of low availability of non-renewable energy resources coupled with the requirements of large quantities of energy for Building materials like cement, the importance of using industrial waste cannot be under estimated. During manufacturing of 1 tones of Ordinary Portland Cement we need about 1-1 Tones of earth resources like limestone, etc. Further during manufacturing of 1 tones of Ordinary Portland Cement an equal amount of carbon-di-oxide are released into the atmosphere. The carbon-di-oxide emissions act as a silent Killer in the environment as various forms.

Fly ash is by product from the combustion of pulverized coal in thermal power stations. Fly ash, if not utilized has to be disposed off in landfills, ponds or rejected in river systems, which may present serious environmental concerns since it is produced in large volumes of 100 million tonnes of fly ash annually. In India, disposal of fly ash is only about 15 percent of this amount currently used which is not at all enough to get rid of fly ash disposal menace.

II. PROPERTIES OF MATERIAL

A. Cement

Ordinary Portland cement (43grate) cement conforming to IS 8112 was used. The different laboratory tests were conducted on cement to determine standard consistency, initial and final setting time as per IS 403 I and IS 269–1967. The result are tabulated in table I the result conforms to the IS recommendations.

TABLE I. Properties of cement

S. No	Test Conducted	Result
1	Fineness on cement	97.75
2	Initial setting time	37 mins
3	Final setting time	570 mins
4	Specific gravity of cement	3.15

B. Fine Aggregate

River sand passing through 4.75mm sieve was used. Physical properties of aggregates determined per IS 2386-1968 and the results are given in table II.

TABLE II. Properties of fine aggregate

S. No	Test Conducted	Result
1	Bulk density	1785 kg/m^3
2	Specific gravity	2.67
3	Void ratio	0.472
4	Fineness modulus	2.87

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C. Coarse Aggregate

Coarse aggregates collected from approved quarry and aggregates having size ranging from 10mm to 20mm are used. The tests are carried out or coarse aggregate as per is 2386-1968 and the results are given in table III.

TABLE III. Properties of coarse aggregate

S. No	Test Conducted	Result
1	Bulk density	845kg/m^3
2	Specific gravity	2.81
3	Fineness modules	6.4

D. Fly Ash

Fly ash was obtained from mettur thermal power plant. The specific gravity and specific area of the fly ashes are 2.10 and 380(m^2/kg) respectively. The chemical properties of FA obtained from thermal power plant are given in the table IV. It is usually used in proportion of percent of cement content of the mix.

TABLE IV. Chemical properties of FA

Chemical Properties min% by mass	IS:3812-1981	Fly ash MTPP
SiO_2+Al_2O_3+Fe_2O_3,	70	90.5
SiO_2	35	58
CaO	5	3.6
SO_3	2.75	1.8
Na_2O	1.5	2
L.O.I	12	2
MgO	5	1.91

Fly ash is also used in ternary blend cement concrete with materials including silica fume, ground granulated blast furnace slag and admixtures to produce very high durability concrete.

TABLE V. Effects of fly ash on various aspects of durability

Durability	Fly Ash Effect
Permeation	Reduced, the extent depends on the property. Effect more marked with age.
Chloride ingress	Reduced, depends on curing
Carbonation	Slightly increased at low strength and early ages.
Corrosion	reduced
Sulfate attack	Reduced, recommended for use in guidance for such conditions.
Abrasion Resistance	Generally improved, but depends on age and curing

E. Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully.

F. Activated Fly Ash

Fly ash once considered as a waste material gains importance due to its role as one of the admixture and replacement material for cement in construction industry. Several tonnes of fly ash from thermal plants are available in India. The utilization of fly ash as construction material largely depends on its mineral structure and pozzolanic property. These two properties of fly ash can be enhanced by different methods of activation. Chemical activation of fly ash by adding chemicals in various proportions for the effective inclusion of the ash in cement concrete. The chemical activators destroy the crystalline structure and produce calcium silicate hydrate, which enhances the strength and tolerance capacity of the concrete against corrosive atmosphere.

G. Activation Process

Calcium oxide and sodium silicate are taken in the ratio 1:8 and are heated at about 103°C to activate the chemicals.The fly ash was added to the hot chemicals and mixed well.The mixture was stirred well for uniform mixing.To ensure the proper blending and to remove the lumps the mixture was blended using as blender. It is called activated flyash

Fig. 1. Activated process

III. Mix Proportion

A mix M20, M25 and M30 grade was designed as per IS 10262:2009 and the same was used to prepare the test samples.

TABLE VI. Mix proportion

Water	Cement	Fine Agg	Coarse agg
197	438	663	1256
0.45	1	1.51	2.87

IV. Results and Discussions

The test result of various parameters like compressive strength using cube, split tensile strength using cylinder, flexural strength using prism and flexural behaviour using beam specimens.

A. Compressive Strength

The compressive strength of concrete is determined at the Age of 7 Days, 14days, and 28 Days, using cubes. For the studies on compression strength, cubes are tested with replacements of 10%, 20%, 30%, 40%, 50%and 60% of mass of cement with fly ash and activated fly ash, three cubes are cast for each proportion for fly ash replacements as well as for AFA replacements. The mould used for cube casting was of size 150mmX150mmX150mm. Each mould was provided with a metal base plate having a plane surface. The test result of various compressive strength using cube are given below

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Fig. 2. Testing of cube in CTM

TABLE VII. Compressive strength-cube (MPa)

Replace %	7 days		14 days		28 days	
	FA	AFA	FA	AFA	FA	AFA
0	26.3	--	29.67	--	32.74	--
10	23.50	24.38	25.70	28.47	30.675	32.78
20	24.34	26.34	31.48	33.77	35.38	36.48
30	21.50	22.23	23.45	24.97	25.823	34.32
40	15.25	16.57	19.42	21.34	25.595	30.55
50	15.10	16.78	18.93	20.83	22.76	28.97
60	14.90	15.54	16.24	20.68	22.25	27.48

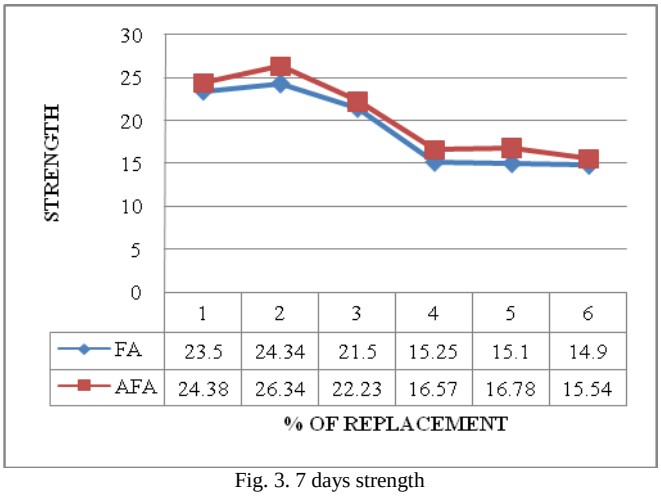

Fig. 3. 7 days strength

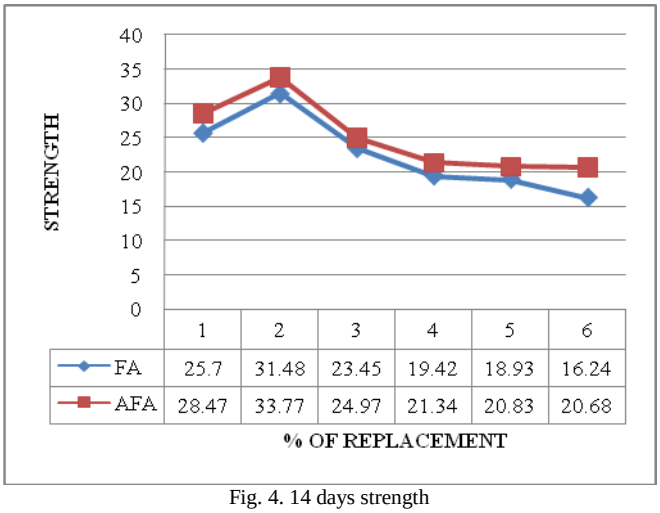

Fig. 4. 14 days strength

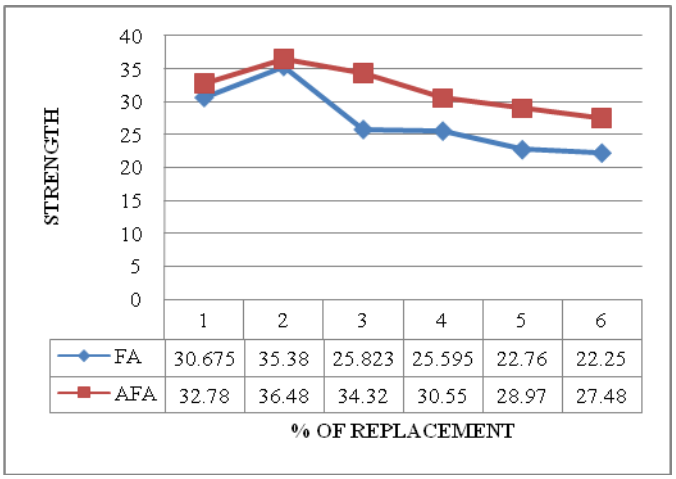

Fig. 5. 28 days strength

B. *Split Tensile Strength*

The split tensile strength of concrete is determined at the age of 7, 28days. For the studies on split tensile strength, cylinders are tested with replacements of 10%, 20%, 30%, 40%, 50%and 60% of mass of cement with fly ash and activated fly ash, three cylinders are cast for each proportion for fly ash replacements as well as for AFA replacements. The cylindrical mould used was of size 150mmX300mm for split tensile strength test. The test result of split tensile strength are given below

TABLE VIII. Split tensile strength (cylinder)

Replacement %	7 Days		28 Days	
	FA	AFA	FA	AFA
0	1.98	--	2.727	--
10	1.84	1.82	2.27	2.80
20	1.76	1.84	2.30	3.0
30	1.68	1.75	2.02	2.72
40	1.60	1.70	1.75	2.51
50	1.31	1.64	1.73	2.28
60	1.25	1.58	1.72	2.17

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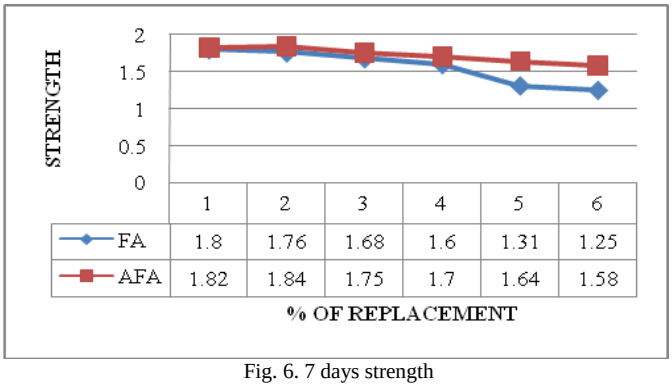

Fig. 6. 7 days strength

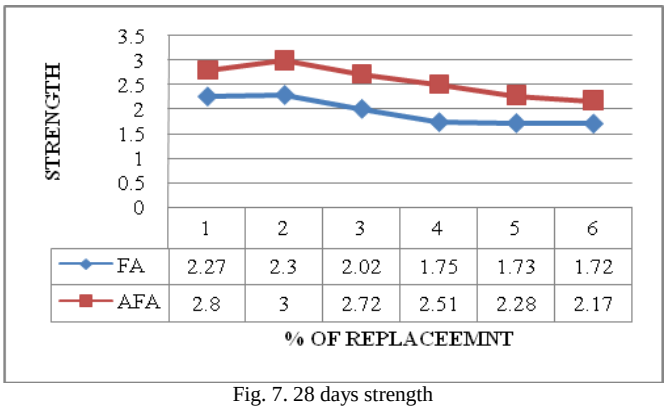

Fig. 7. 28 days strength

C. *Flexure Strength*

The flexure strength of concrete is determined at the age of 7, 28days. For the studies on flexure strength, prisms are tested with replacements of 10%, 20%, 30%, 40%, 50%and 60% of mass of cement with fly ash and activated fly ash, three prisms are cast for each proportion for fly ash replacements as well as for AFA replacements. The mould used was of size 100mm X100mm X500mm.Each mould was provided with a metal base plate having a plane surface. The base plate support the mould durin g the filling without leakage and it was attached to the mould by screws and coating of mould oil was applied between the interior surfaces of the mould and the base plate. The test result of flexural strength are given below

TABLE IX. Flexural Strength (prism)

Replacement %	7 Days		28 Days	
	FA	AFA	FA	AFA
0	2.12	--	3.42	--
10	2.05	2.11	3.70	4.12
20	1.97	2.06	3.97	4.32
30	1.61	1.94	3.51	3.94
40	1.46	1.50	2.86	3.77
50	1.32	1.41	2.82	3.21
60	1.18	1.28	2.78	2.98

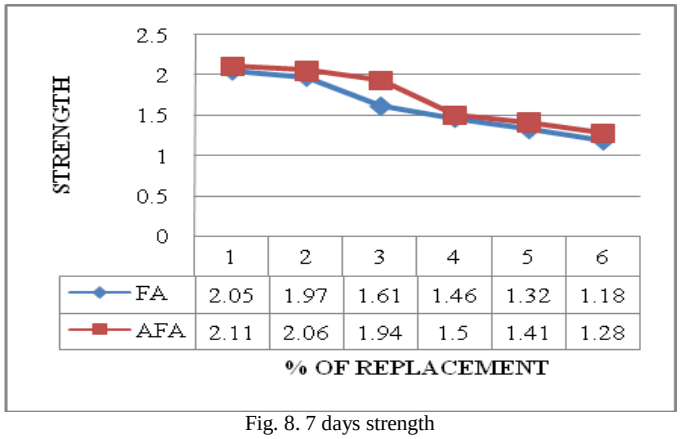

Fig. 8. 7 days strength

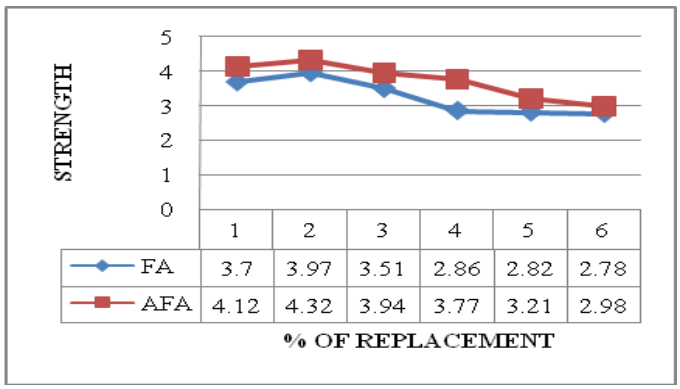

Fig. 9. 28 days strength

V. CONCLUSION

In this investigation, mechanical properties and flexural behavior of AFA concrete and control concrete were studied and compared. The weight replacement of cement used were 10%, 20%, 30%, 40%, 50% and 60% and the following conclusion are arrived. In the study of mechanical properties it is observed that AFA specimen showed better strength. In the strength study on cubes it is conformed that AFA concrete shows a better result in comparison to control specimens and fly ash specimens. It is also noted that the AFA concrete shows strength gain at early ages of 7 days in comparison to fly ash concrete. Fly ash concrete has a good pozzolanic property and compressive strength during aging. The quality and efficiency of FA further increased by means of chemical activation. Activation method employed in this study is simple and does not require additional equipments or new technology. For the purpose, chemicals like calcium oxide and sodium silicate which are easily available have been successfully used to corrode the crystalline structure of glassy beads of FA and start its activation. The split tensile strength test on cylinders showed that 20% AFA replacement gives better strength when compared to CM and FA concrete. The flexure performance of AFA is comparable with OPC. The superior performance of chemically AFA compared to other type of activation gives scope for further research in this field.

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