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A Study on Strength Parameters of Partially Replacement of Cement by Fly Ash and Activated Fly Ash Concrete

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***Abstract*— Fly ash is one of the most important material now a days, which is available in large quantities and it is the retained or waste product of coal hat is burnt in the power plant. The main reason behind this is to reduce the level of global carbon-di-oxide, hence encouraging the researches to search for other sustainable material. Cement, which is the most popularly used product contributes 7% of global carbon-dioxide emission. Therefore it has become the need to use some other alternative material to reduce the use of cement in concrete. And this could be an essential step in reducing the cost, saving energy, controlling pollution etc. The main focus of this experiment is to replace the cement by fly ash and activated fly ash in the concrete. This content highlights the use of fly ash and the usage of calcium oxide(Cao, powder form) and sodium silicate(Na_2Sio_3, liquid form) in the ratio of 1:8 for activation and for improving the property of fly ash. In this context we have studied compressive strength, split tensile strength and flexural strength. The replacements of Fly ash and activated fly ash have been studied in the percentage wise of 20%, 30%, 40% and 50%. The mix design used in M30 with 0.45 ratio of water/cement.**

Keywords- Fly ash, Activated Fly ash, Compressive strength, split tensile strength, flexural strength

I. INTRODUCTION

Cement is one of the popular binding agent used since many decades for the construction activity. Concrete is a heterogeneous component, consisting of the mixture of cement, sand, course aggregate and admixture. Concrete is recognized by the properties like strength, durability and resistant power. Many alternative materials have been used for cement replacement. In order to save cost, power, energy and for the environmental protection and low usage of naturally available resources. The materials used here are fly ash rice husk ash, silica fumes etc. Several researches have been carried out using these above mentioned materials in order to increase the quality of concrete with required strength and durability.

Fly Ash: Fly ash is a fine powder particle, consisting of components like SiO_2, Al_2O_3, Fe_2O_3 and CaO. Fly ash popularly used as pozzolanic material all over the world. The type of the collection system used defines the characteristics of the fly ash. The collection system is the composition of mechanical collectors, fabric filters, wet scrubbers and electrostatic precipitators. According to studies it has been found that about one ton of Portland cement production releases 0.87 tones of Carbon-dioxide in the environment, we focus on the use of fly ash. The use of fly ash in the concrete mixture not only improves the quality and strength of the concrete but also controls the pollution in the environment. The importance of the fly ash has gained popularity, such that now a days it has become the most commonly used ingredient in the concrete and making it a high performance component. Extensive research on fly ash properties denotes that fly ash can be used as SCM, in construction industry.

*Fly Ash Effects on concrete***:** The extensive use of fly ash material has been found to increase the absolute volume of cementitious materials(cement + fly ash) when compared to non fly ash materials, hence the paste volume increases, which leads to the reduced aggregate particle interference and helps in enhanced workability of concrete. The fly ash has the so- called "Ball Bearing" effect, this is because the fly ash consist of minute spherical shaped particle. By making use of fly ash in air-entrained and non air-entrained particle mixture it reduces the bleeding hence providing the greater fine volumes and reduced water content for workability. The characteristics and the amount of fly ash describes the setting time of fly ash. The type of the cement influences the strength of the fly ash. Curing temperature is studied for the equivalent 28 days compressive strength compared to the non fly ash concrete.

II. LITERATURE & REVIEW

1.Sunilaa George & Dr. R.Thenmozhi (2011) [1] [2]**:** Studied the behavior of Activated fly ash concrete. The effectiveness of fly ash activation by CaOand Na2SiO3 is verified by scanned electron microscope. Scanning electron microscopy shows that FA is composed mainly of smooth-surface glass beads of different sizes. On the other hand, glass beads in AFA are severely corroded.

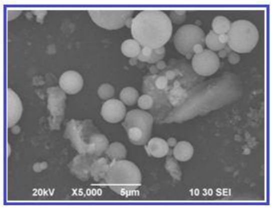

Fig. 1a: FA

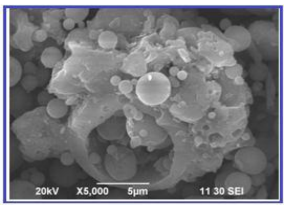

Fig. 1b: AFA

2.Fan and others (1999): Proposed a method of Fly ash activation with addition of Ca(OH)2 and Na2SiO3. In their studies, a low-calcium fly ash was obtained from a power plant in China, was mixed with Ca(OH)2(in certain proportion by weight), Na2SiO3 and *WIS* = 3:l

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and the mixture held at Constant temperature of 55 " C, until Ca(OH)2 disappeared. The above sample was wet ground for 40 min. and dried at a temperature of 120" C, to yield the activated fly ash **(**AFA). They have concluded that the activity of the activated fly ash by the above method has increased which can accelerate cement early hydration and promote setting and hardening. They have recommended a composite.

3.Sandeep Mane1 and Barzin Mobasher an experimental study was conducted to evaluate the mechanical properties of mortar containing fly ash subjected to both physical and chemical activation. Mortar specimens containing class F fly ash and various activators on were prepared. . In order to activate the hydration reactions, additives such as sodium hydroxide (NaOH) and potassium hydroxide (KOH) were used at rate 2.5% of total binder weight. Experimental data indicate that increasing the fly ash content from 20% to 50% results in a favorable influence on compressive strength whereas the flexural and fracture properties remain virtually at the same level.

4.Cengiz Duran Ati carried out investigations to evaluate the strength properties of high-volume fly ash (HVFA) roller compacted and superplasticised workable concrete cured at moist and dry curing conditions. Concrete mixtures made with 0%, 50% and 70% replacement of normal Portland cement (NPC) with two different low-lime Class F fly ashes, good and low quality, were prepared. The influence of loss on ignition (LOI) content of fly ash on water demand and the strength of concrete was also discussed. . It was concluded that HVFA concrete was an adequate material for both structural and pavement applications.

5.Shi anti others (1994**):** Studied the effect of some sodium based activators (Na_2SO_4 , NaOH, Na:, COI and Na_2SiO_3, - all chemical reagent grade) on the Strength development of two types of blended cements made with a natural pozzolan. The two blended systems consisted of

(a) Natural pozzolana (from Guatemala) and commercial slaked lime and

(b) Natural pozzolana and Portland cement.

III. MATERIALS USED

A. *Cement:*

Cement in general can be defined as a material which possesses very good adhesive and cohesive properties which make it possible to bond with other material to form compact mass Modern Portland cement is made by mixing substances containing lime, silica, alumina, and iron oxide and then heating the mixture until it almost fuses. . Cement with high aluminates content is used for fire proofing, because it is quick-setting and resistant to high temperatures. cement with a high sulfate content is used in complex castings, because it expands up on hardening, filling smalls paces.

Table 1: Physical and Chemical properties requirement of OPC according to I.S.12269- 1987s

Sl. No	Properties	Recommendations I.S.12269- 1987
1	Specific Gravity	3.15
2	Initial setting time	Should not be less than 30min
3	Final setting time	Should not exceed 600min.
4	Soundness : By Le Chatrliermould By Autoclave	Should not exceed 10mm Should not exceed 0.8%
5	Finesses	Should not be less than $225m^2/kg$
6	Normal consistency	29.7 %
7	Alkalies	Should not exceed 0.6%
8	Chlorides	Should not exceed 0.05%
9	Magnesia (MgO)	Should not exceed 6%
10	Lime Saturation Factor	Should not be less than 0.8 and not exceed 1.02
11	Alumina Iron ratio	Should not be less than 0.66
12	Sulphuric Anhydride(SO_3)	Should not exceed 3%
13	Loss on Ignition (LOI)	Should not exceed 4%

B. *Fine Aggregate(FA):*

Sand plays an important role in concrete. Sand must be well graded so that it helps in filling the voids between the coarse aggregate. Sand used should be from organic matter & silt. The particle size of fine aggregate used in this study was such that it conform to zone II of IS: 383-1970

. Table 2**:** Physical Properties of Fine Aggregate

Sl.No.	Properties	Values
1	Specific gravity	2.69
2	Fineness	2.52
3	Bulk Density	1700 kg/m^3
4	Water Absorption	1%

C. *Coarse Aggregate:*

Crushed aggregate improve the strength because of interlocking of angular particles, while rounded aggregate improves the flow ability of concrete. Coarse aggregate used in this experiment was locally available crushed aggregate passing through 20mm IS sieve and conforming to IS: 383-1970.

Table 3: Properties of coarse aggregate

Sl.No.	Properties	Values
1	Specific gravity	2.65
2	Fineness	7.06
3	Bulk Density	1440 kg/m^3
4	Water Absorption	0.6%

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D. Fly Ash:

Fly ash that results from burning sub-bituminous coals is referred as ASTM Class C Fly Ash or high calcium Fly Ash, as it typically contains more than 20 percent of CaO. On the other hand, fly ash from the bituminous and anthracite coals is referred as ASTM Class F Fly Ash or low calcium Fly Ash. It consists of mainly an alumino silicate glass, and has less than 10 percent of Cao.

Table 4: Chemical composition of fly ash used

OXIDES	MASS %
SiO_2	59.20
Al_2O_3	24.30
Fe_2O_3	6.12
CaO	2.8
Na_2O	0.25
K_2O	3.10
TiO_2	1.10
MgO	1.80
P_2O_5	0.36
SO_3	1.85
LOI	1.50

- Mix Proportion:
  - Cement = 437.77 Kg/m3
  - Fine aggregates = 650.92 Kg/m3
  - Coarse aggregates = 1091.85 kg/m3
  - Water = 197 liters
  - Water cement ratios = 0.45

The mix proportion per cubic meter of concrete then becomes

Water	Cement	Fine aggregate	Coarse aggregate
197lts.	438 kg	651 kg	1092 kg
0.45	**: 1**	**: 1.4**	**: 2.49**

IV. TESTS

A. Slump Cone Test:

The slump test does not measure the workability of concrete although ACI 116R – 90 describes it as a measure of consistency, but the test is very useful in detecting variations in the uniformity of a mix of given nominal proportions.

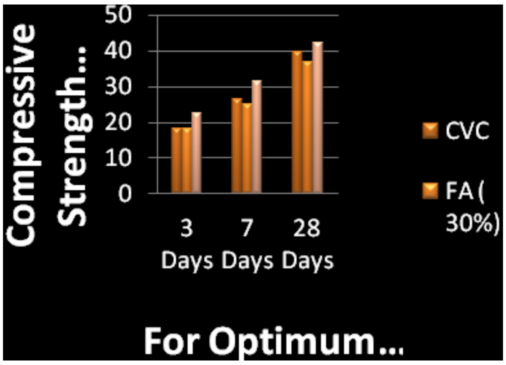
Table 5: Slump values

Grade	M30 with 20% Fly ash	M30 with 30% Fly ash	M30 with 40% Fly ash	M30 with 50% Fly ash
Slump mm	70	64	60	56

B. Compressive strength test:

In the present investigation the cubes were casted with fly ash and activated fly ash replacing cement, and tested. The casted cubes kept for curing and tested after 3days, 7days, and 28days and the capacity of concrete cube noted in KN .i.e. Force (P) by placing on any one side of the cube. The cross sectional area (A) of cube is 225cm^2. The compressive strength is represented in N/mm^2.

The Mathematical representation of compressive strength, $\sigma c = P/A$.



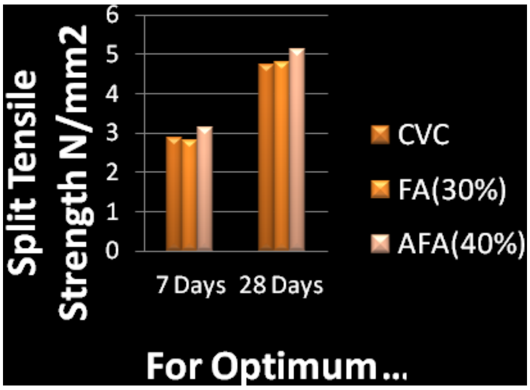
Graph 1: Comparison of Compressive strength of CVC, FA, and AFA Concrete for optimum replacement values

C. Tests for Split Tensile Strength:

The tensile strength of concrete is most often evaluated using a split cylinder test, In which a cylindrical specimen is placed on its side and loaded in diametrical compression, so to induce transverse tension. When the cylinder is compressed by the two plane-parallel faceplates, situated at two diametrically opposite points on the cylinder surface then, along the diameter passing through the two points, the major tensile stresses are delve points, the major tensile stresses are developed which, at their limit, reach the fracture strength value, fcs:

$$fcs = 2F/\pi dl$$

Where: F is the fracture compression force acting along the cylinder generatrix, d is the cylinder diameter; l is the cylinder length.



Graph 2: Comparison of Split Tensile strength of CVC, FA, and AFA Concrete for optimum replacement values

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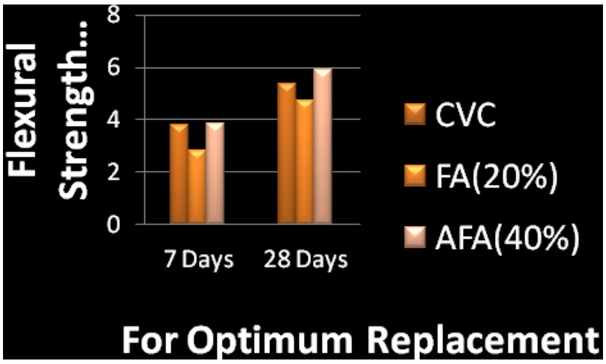
D. Tests for Flexural Strength:

This test is performed according to IS 516 – 1959. The flexural strength of the specimen shall be expressed as the modulus of rupture *f*b, which, if '*a*' equals the distance between the line of fracture and the nearer support, measured on the centre line of the tensile side of the specimen, in cm, shall be calculated to the nearest 0.5 kg/sq cm as follows:

$$f_b = p*l/ bd2$$

b = measured width in mm of the specimen,
d = measured depth in mm of the specimen at the point of failure,
l = length in mm of the span on which the specimen was supported,
p = maximum load in KN applied to the specimen



Graph 3: Comparison of Flexural strength of CVC, FA, and AFA Concrete for optimum replacement values.

V. CONCLUSION

From all of these above experimental details it is been found and we conclude that, the workability of the concrete decreases with the increase in the fly ash content in the concrete. The fly ash replaces the OPC cement in concrete by 30% and activated fly ash up to 40% for improved results and are found to be optimum and nearer to accurate values. The compressive strength of fly ash concrete at 30% replacement after 28 days is 36.9 N/mm2 which is lesser than conventional concrete by 6.81%.Activated fly ash concrete has higher compressive strength compared to conventional & fly ash concrete. The compressive strength increases by 6.16% & 12.5% higher than CVC & Fly ash concrete. The split tensile strength of fly ash blended concrete is more than conventional concrete. The 30% fly ash being optimum replacement with split tensile strength of 1.9% higher than CVC at 28 days.The split tensile strength of AFA concrete is 7.8% & 6.05% higher than CVC & fly ash concrete respectively. The optimum AFA replacement is 40%.The flexural strength of fly ash concrete is optimum at 20% replacement and decreases with increases in fly ash content. The optimum value is lesser by 9.4% compared to CVC at 28 days.The flexural strength of AFA concrete increases with increase in AFA content up to 40% and is the optimum value for replacement. Flexural strength of AFA concrete at 40% replacement is 9.1% and 19.3% is higher than CVC & fly ash concrete respectively after 28 days.From the overall experimental results we can conclude that, by activating the fly ash in concrete gives good compressive, split tensile & flexural strength up to 40% replacement after 28 days strength.

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