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A FEASIBILITY STUDY ON HIGH STRENGTH CONCRETE WITH MINERAL ADMIXTURES FLY ASH AND SILICA FUME

K. Naga Sateesh*[1], I. Siva reddy*[2], A. Pavan Sankar*[3], J. Vamsi Rathnakar*[4], A. Sai Durga Prasad*[5], K. Venkateswara rao*[6]

*[12345]Under Graduate Students, Department of Civil Engineering, Seshadri Rao Gudlavalleru Engineering College, Gudlavalleru,Andhra Pradesh, India.

*[6]Associate Professor, Dept. of Civil Engineering, Seshadri Rao Gudlavalleru Engineering College, Gudlavalleru,Andhra Pradesh, India

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ABSTRACT

In this experimental investigation stands for improving the properties of concrete with respect to strength and durability characteristics especially in this aggressive investigation review states on addition of Cement with mineral admixtures and superplasticizer. High strength concrete appears to be better choice for strong and durable structures. A large amount of by-product or wastes such silica fume and fly ash. are generated by industries, which causes environmental as well as health problems due to dumping and disposal. Proper introduction of silica fume and fly ash in concrete improves both the strength and durability characteristics of the concrete. The effects of flyash on workability, density and on various strength properties of high strength concrete M70 of grade concrete have been studied. The silica fume content varies from (5%, 10% and 15%) and fly ash contents varies from (10%, 20%, 30%) by volume of cement is used in concrete. For this purpose along with a Control Mix, 18 sets were prepared to study the compressive strength, tensile strength and flexural strength. Each set comprises of 9 cubes, 9 cylinders and 9 beams. All specimens are water cured and tested at the age of 7 and 28-days. Super plasticizer is to be used to increase workability. Ductility and bond of concrete is to found to increase in silica fume and fly ash in the concrete as observed from the Compressive test, Tensile Strength and Flexural Strength tests were performed in the hardened state. In this study optimum percentage silica fume and fly ash arrived at the keeping optimum percentage. The strength and durability properties of M70 grade of concrete was studied.

Keywords: Silica Fume, Fly ash, Compressive Strength, Split Tensile Strength, Flexural Strength and acid attack.

I. INTRODUCTION

Concrete is the most important material used for construction. In the modern world, the use of concrete has be increasing and hence demand for special types of concrete is also in large quantity. One among those special types of concrete is High Strength Concrete (HSC). HSC is defined as a concrete meeting special combination of strength and uniformity requirements that cannot always be achieved routinely using conventional constituents and normal mixing, placing, and curing practice. The term High Strength Concrete (HSC) is suggested for concrete mixtures that possess high workability, high-strength, and high-durability. But the proportions are designed or engineered to provide the strength and durability needed for the structural and environmental requirements. The raw materials needed for the manufacture of Portland cement (PC) are available in many places, and the energy requirements for its production may be considered to be relatively modest. They are responsible for substantial "environmental unloading" because their disposal can be hazardous to be environment and higher utilization of them can result in reduction of greenhouse gas emission from cement industry. Some of them or condensed silica fume (SF), Fly ash. In this paper these two mineral admixtures are replacing cement by certain percentage.

II. METHODOLOGY

We can test testing of specimens are tabulated and observed . A number of trails are prepared by varying water cement ratio until the compressive strength of the specimens reached the target compressive strength. After that specimens are prepared by partially replacing cement with fly ash at 10%, 20%, 30% and so on and are tested for 7 and 28 days strengths. After the optimum percentage of fly ash is obtained, cement is replaced with silica fume at 5%, 10% and 15%. The strengths are obtained for different replacements and strength are calculated and strength are calculation.

III. EXPERIMENTAL INVESTIGATION

Experimental investigation consists of casting and testing of 18 sets along with control mix. Each set comprises of 9 cubes, 9 cylinders and 9 beams for determining compressive, tensile and flexural strengths respectively. Fly ash content varies from (10%,20% and 30%) by volume of cement is used in concrete. All specimens are water cued and tested at the age of 7and 28-days. Workability of wet mix is found to be reduced with increase fly ash content. Super plasticizer is to be used to increase workability. Ductility and bond of concrete is to found to increase in fly ash concrete. In this study optimum percentage fly ash arrived at the keeping optimum percentage addition of fly ash constant and replacing granite silica fume by (5%,10%,15%,). The different admixtures like silica fume. Cube section dimension is of 15cmx15cmx15cm, cylinder section dimension is 15cmx30cm and prism dimension is 50cmx10cmx10cm. The moulds are applied with a lubricant before placing the concrete. After a day of casting, the moulds are removed. The cubes, cylinders and prisms are moved to the curing tank carefully.

3.1 Materials

The constituent materials used in these studies are given below:

1. Cement (Ultra-tech gold OPC 53 grade)
2. Fine aggregate
3. Coarse aggregate
4. Fly ash
5. Silica fume
6. Glenium SKY 8630 (chemical admixture)
7. Water

Table 3.1: Experimental values of Ultra-tech cement (IS code 2523)

S. No.	Property	Value Obtained Experimentally	Requirements as per IS codes
1.	Normal Consistency	34%	IS 4031- 1988(part-4)
2.	Specific gravity	3.12	3.15
3.	Fineness of Cement	5.6%	10%
4.	Initial setting time Final setting time	44min 460min	As per 12269 -2013 30 min. Minimum 600 min. Maximum
5.	Soundness test	Expansion 7 mm	IS 4031-1988(Part3)
6.	Compressive strength	1.3 days-15.2 MPA 2.7days-16.3MPA 3.28days-23.1MPA	IS 269-2015

The fine aggregate which is the inert material occupying 60 to 75 percent of the volume of mortar must get hard strong nonporous and chemically inert. Fine aggregates conforming to grading zone II with particles greater than 2.36 mm and smaller than 150 mm removed are suitable.

PROPERTIES OF FINE AGGREGATE

properties	values
Specific gravity	2.6
Fineness	2.68

COARSE AGGREGATE

FINE AGGREGATE

Sand shall be obtained from a reliable supplier and shall conform with IS code:2386- 1986 (part 3)for fine aggregates. It should be clean, hard, strong, and free of organic impurities and deleterious substance. It should be inert with respect to other materials used and of suitable type with regard to strength, density, shrinkage and durability of mortar made with it. Grading of the sand is to be such that a mortar of specified proportions is produced with a uniform distribution of the aggregate, which will have a high density and good workability and which will work into position without segregation and without use of high water content. The fineness of the sand should be such that 100% of it passes standard sieve No.

Machine crushed hard granite chips of 65% passing through 20 mm sieve and retained on 12 mm sieve and 33% passing through 12 mm and retained on 10 mm sieve was used a coarse aggregate throughout the work. following test are carried out on Coarse Aggregate as per IS 2386- 1986 (part 3).

TESTS ON COARSE AGGREGATE

properties	Properties values
Specific gravity	2.7
Fineness modulus	7.42

FINE AGGREGATE

Sand shall be obtained from a reliable supplier and shall conform with IS code:2386- 1986 (part 3)for fine aggregates. It should be clean, hard, strong, and free of organic impurities and deleterious substance. It should be inert with respect to other materials used and of suitable type with regard to strength, density, shrinkage and durability of mortar made with it. Grading of the sand is to be such that a mortar of specified proportions is produced with a uniform distribution of the aggregate, which will have a high density and good workability and which will work into position without segregation and without use of high water content. The fineness of the sand should be such that 100% of it passes standard sieve No.8.

FLY ASH

Fly ash is used to lower the cost and to improve the performance of PCC. Typically, 15 percent to 30 percent of the portland cement is replaced with fly ash, with even higher percentages used for mass concrete placements. An equivalent or greater weight of fly ash is substituted for the cement removed. The substitution ratio for fly ash to portland cement is typically 1:1 to 1.5:1. A mix design should be evaluated with varying percentages of fly ash. Time versus strength curves can be plotted for each condition. To meet specification requirements, curves are developed for various replacement ratios and the optimum replacement percentage ratio is selected. A mix design should be performed using the proposed construction materials. It is recommended that the fly ash concrete being tested incorporates local materials in performance evaluation Cement Factors. Because fly ash addition contributes to the total cementitious material available in a mix, the minimum cement factor (portland cement) used in the PCC can be effectively reduced for FAC. The ACI acknowledges this contribution and recommends that a water/ (cement plus pozzolan) ratio be used for FAC in lieu of the conventional water/cement ratio used in PCC.Fly ash particles react with free lime in the cement matrix to produce additional cementitious material, and thus, to increase long-term strength

PROPERTIES OF FLY ASH

S.No	Physical Properties	Results
1	Physical State	Micronized Powder

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2	Odour	Odourless
3	Appearance	White Colour Powder
4	Colour	White
5	Pack Density	0.76gm/Cc
6	Ph Of 5% Solution	6.90
7	Specific Gravity	2.63
8	Moisture	0.058%

SILICA FUME

Silica fume is a byproduct of producing silicon metal or Ferro silicon alloys. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolan. Concrete containing silica fume can have very high strength and can be very durable. Silica fume is available from suppliers of concrete admixtures and, when specified, is simply added during concrete production. Placing, finishing, and curing Silica Fume concrete require special attention on the part of the concrete contractor. Silicon metal and alloys are produced in electric furnaces as shown in this photo. The raw materials are quartz, coal, and woodchips. The smoke that results from furnace operation is collected and sold as silica fume, rather than being land filled. Perhaps the most important use of this material is as a mineral admixture in concrete. Silica fume consists primarily of amorphous (non-crystalline) silicon dioxide (SiO_2). The individual particles are extremely small, approximately 1/100th the size of an average cement particle. Silica-fume concrete does not just happen. A specifier must make a conscious decision to include it in concrete to achieve desired concrete properties. Assistance in specifying silica-fume concrete for high strength or increased durability can be obtained from the SFA or from major admixture suppliers. Silica fume for use in concrete is available in wet or dry forms. It is usually added during concrete production at a concrete plant as shown in the photo. Silica fume-concrete has been successfully produced in both central-mix and dry-batch plants. Assistance is readily available on all aspects of handling silica fume and using it to produce consistent, high-quality concrete.

PROPERTIES OF SILICA FUME

S.No	Physical Properties	Results
S 1	Physical State	Micronized Powder
2	Odour	Odourless
3	Appearance	White Colour Powder
4	Colour	White
5	Pack Density	0.76gm/Cc
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8	Moisture	0.058%

GLANIUM

The Master Glenium SKY 8630 product offering from BASF comprises new generation high-range water-reducing admixtures that are specially formulated for concrete applications where slump retention, high/early strengths and durability are required. Concrete mixtures containing these premier products can be optimized for delivery in remote locations and for use in hot and cold climates

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Properties	Test result
Aspect	Light brown liquid
Relative density	1.08 ± 0.01 at 25°C
P_H	>6
Chloride ion content	<0.2%

IV. RESULTS AND DISCUSSION

4.1 Compressive Strength

The cs of fa and sf mixes at various ages (7 and 28 days) are represented in figure. 4.1. The cs of sf concrete is greater than that of opc concrete at all ages, and the gain in strength increases with the increase of fa and sf content. However, the fa mix with 20 percent and sf mix with 10 percent. The interaction of reactive silica of pozzolan with calcium hydroxide (ch) produces extra calcium silicate hydrate (c–s–h) due to cement hydration [27]. As a result, the cs of the mixes containing sf was more significant than that of the opc mix, even in the early ages. At early ages (7 and 28 days) . Fa20 blended mix had lower cs than the opc mix, whereas at later ages (7 and 28 days), it exhibited higher cs than that of opc mix. This low early strength is consistent with the result of m.a. Megat johari et al. [28]. Both fa20 and fa30 binary blended concrete mixes showed lower cs than the opc mix, irrespective of age. Hence it can be concluded that sf is a preferred material compared to fa, as sf contributes to better cs at early and later ages.

Table 4.1: Compressive Strength Test Results For Various Percentages Of Mineral Admixtures

MIX	COMPRESSIVE STRENGTH (N/mm^2)	
	7 days	28 days
Conventional	53.08	79.39
FA10%	48.37	75.69
FA 20%	51.21	82.03
FA30%	49.14	77.23
FA20%+SF5%	57.95	83.15
FA20%+SF10%	**62.07**	**87.36**
FA20%+SF15%	59.87	84.66

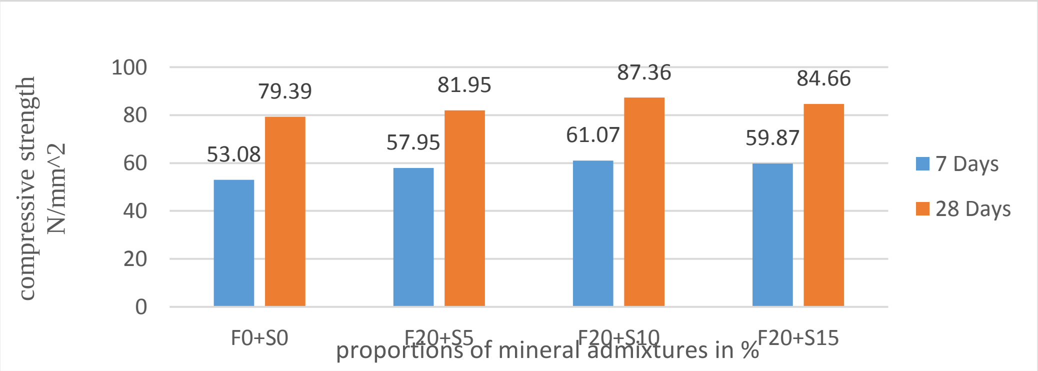

Fig4.1: Compressive Strength for various percentages of Fly ash and Silica fume

4.2 Split Tensile Strength

Figure. 4.2 displays the ts of fa and sf mixes at various ages (7 and 28 days). At all ages, the ts of fa and sf concrete is greater than that of opc concrete, and the gain in strength increases as the sf content increases. The sf mix with 10% sf and fa mix with 20% on the other hand, achieved the desired target strength. The presence of sf particles fills the pores in the c-s-h gel structures while acting as a nucleus to form a strong bond with the c-s-h

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gel particles. Ts exhibits the same trend as cs at early and later ages. Fa30 binary blended mix had lower ts than opc mix at early ages (7 and 28 days) but higher ts than opc mix at later ages (90 and 180 days). Regardless of age, both the fa20 and fa30 binary blended concrete mixes had lower ts than the opc mix. As a result, it can be concluded that sf is a preferred material over fa because sf contributes to better ts at both early and late ages

Table 4.2: Split Tensile Strength Test Results for various percentages of mineral admixtures

MIX	Split Tensile Strength (Mpa)	
	7 days	**28 days**
Conventional	3.39	4.15
FA10%	3.24	4.06
FA 20%	3.34	4.22
FA30%	3.27	4.10
FA20%+SF5%	3.55	4.25
FA20%+SF10%	**3.67**	**4.36**
FA20%+SF15%	3.61	4.29

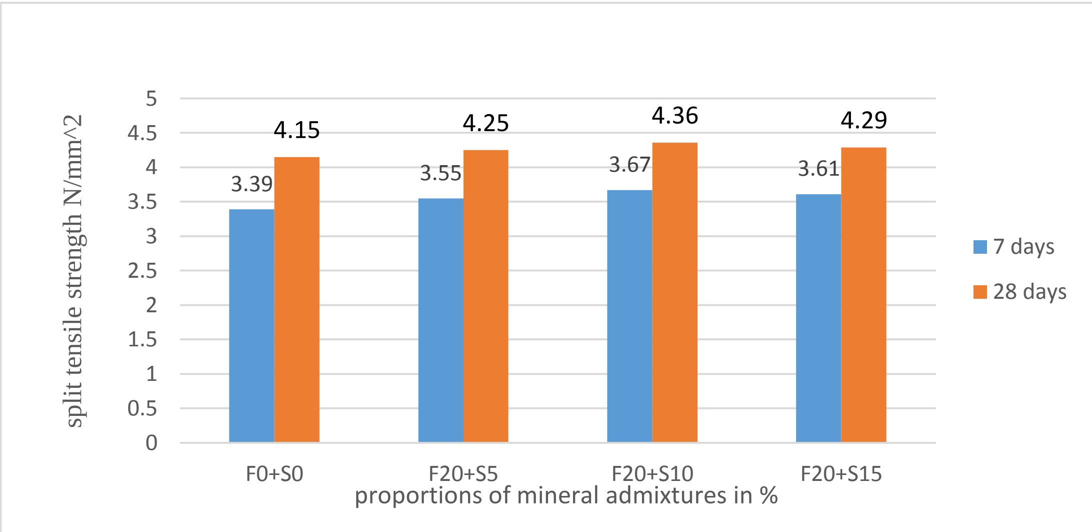

Fig4.2: Split Tensile Strength for various percentages of Fly ash and Silica fume

4.3 Flexural Strength

Figure. 4.3 displays the FS of FA and SF mixes at various ages (7 and 28 days). At all ages, the FS of FA and SF concrete is greater than that of OPC concrete, and the gain in strength increases as the SF content increases. The SF mix with 10% SF and FA mix with 20% on the other hand, achieved the desired target strength. The presence of SF particles fills the pores in the C-S-H gel structures while acting as a nucleus to form a strong bond with the C-S-H gel particles. FS exhibits the same trend as CS at early and later ages. FA30 binary blended mix had lower FS than OPC mix at early ages (7 and 28 days) but higher FS than OPC mix at later ages (90 and 180 days). Regardless of age, both the FA20 and FA30 binary blended concrete mixes had lower FS than the OPC mix. As a result, it can be concluded that SF is a preferred material over FA because SF contributes to better FS at early and late ages

Table 4.3: Flexural Strength Test Results for various

MIX	Flexural Strength (Mpa)	
	7 days	**28 days**
Conventional	5.10	6.23

FA10%	4.86	6.09
FA 20%	5.00	6.33
FA30%	4.90	6.15
FA20%+SF5%	5.32	6.38
FA20%+SF10%	**5.51**	**6.54**
FA20%+SF15%	5.41	6.44

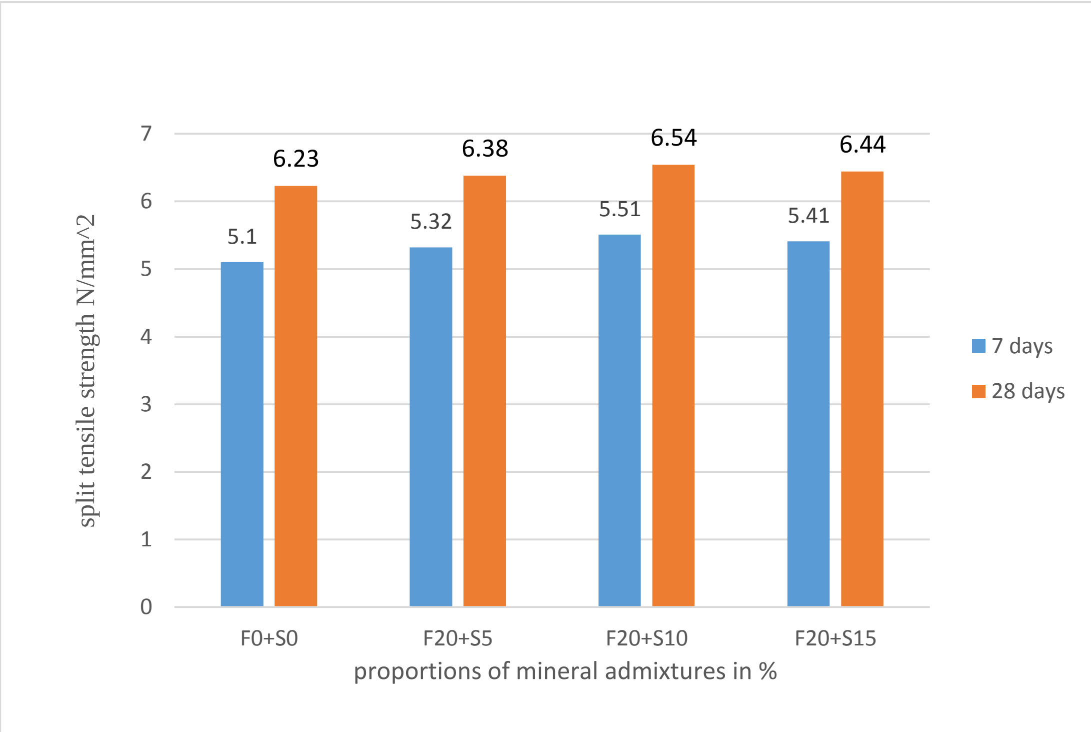

Fig4.3: Flexural Strength for various percentages of Fly ash and Silica fume percentages of mineral admixtures

4.4 Durability Studies

To check the Acid resistance of concrete Sulphuric Acid (H2SO4) is selected. The concentrations of acids in water are taken as 2%. The standard specifications for this study are IS 516-1959 and ASTM C666-1997.

Table 4.4.1: Summary of brief details for durability study

Acids used	**H_2SO_4**
Concentrations for trails	2% in water
Number of days of testing	28 days

4.4.1 Preparation of 2% H2SO4 per 15 litres of Water

The volume of acid to mix in water is calculated by the formula

C1V=C2V2

C1 is the Concentration of H2SO4 = 98%

V1 is the Volume of acid to be added

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C2 is the required concentration = 2%

V2 is the required volume of acid= 15

Volume of H2SO4 (V1) = C2V2/C1

= 2×20/98

=0.408 litres

i.e., to prepare 15 solutions of H2SO4, volume of acid required is 0.306 litres

Table 4.4.1: Weight loose of cubes after H2SO4 acid curing in 28 days

MIX	Weight of cube after casting (kg)	Weight of cube after 28 days (kg)	Weight loose of cube after 28 days (kg)
Conventional	8.56	7.60	0.96
FA10%	37	7.55	0.82
FA 20%	8.21	7.58	0.63
FA30%	7.98	6.78	1.24
FA20%+SF5%	8.03	7.17	0.86
FA20%+SF10%	**8.16**	**7.68**	**0.48**
FA20%+SF15%	7.95	6.90	1.05

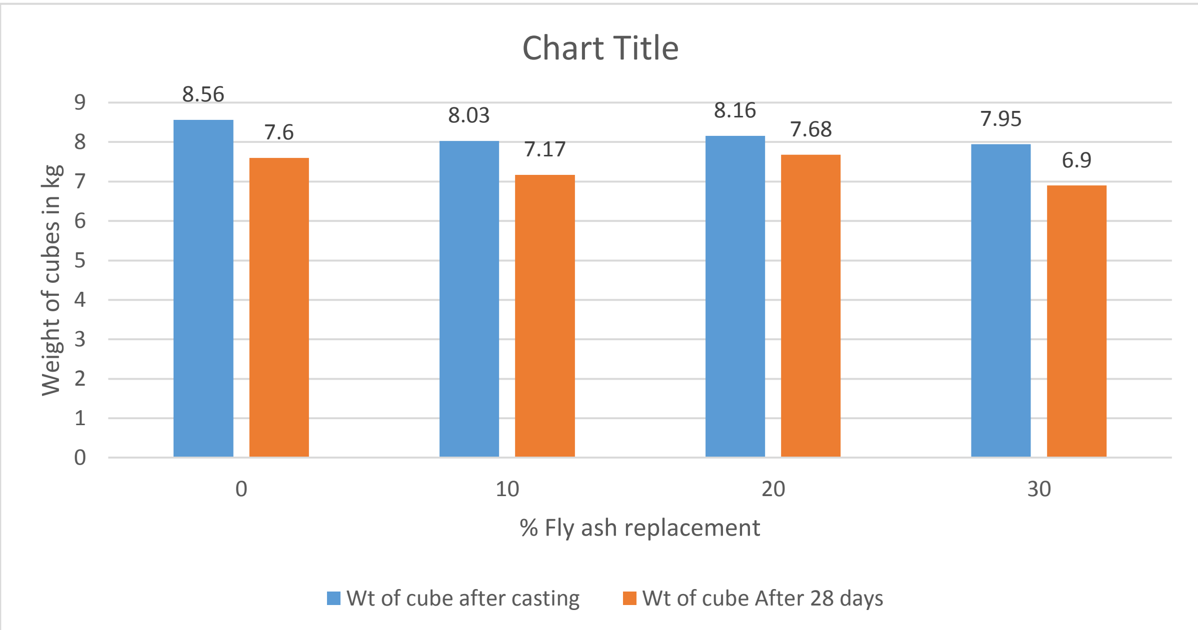

Fig:-4.4.1 Durability of concrete with mineral admixtures

V. CONCLUSION

Based on the analysis of experimental results and discussion there upon the following conclusions can be drawn:

1. Addition of 10% Silica Fume and 20% Fly ash to M70 Conventional concrete mix, there is an increase in compressive strength up to 10.05% over conventional concrete.

2. Split Tensile Strength increases by 5.06% with addition of 10% Silica Fume and 20% Fly ash to M70 Conventional concrete.
3. Flexural strength increases by 5% with addition of 10% Silica Fume and 20% Fly ash and to M70 Conventional concrete.
4. Durability test results shows there is reduction in strength lower when Cement is replaced with Fly ash and Silica fume, Compared to conventional concrete.

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