Experimental Investigation on Strength of M30 Concrete with Various Mineral and Chemical Admixtures

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Abstract: The present trend in the concrete technology is of increasing the strength of concrete to meet the demands of modern construction material. These factors can be achieved in concrete by adding various blending materials with cement or separately to concrete. The materials suitable for blending are ground granulated blast furnace slag, silica fume, and fly ash etc., The experimental investigations have been made to study the suitability of the use of chemical admixtures for the replacement of cement & water in concrete in order to reduce the environmental problems. This experimental investigation is aimed to utilize such mineral and chemical admixtures as a partial replacement for cement in concrete. M30 grade concrete is taken for investigation. The cement is replaced by fly ash and ground granulated blast furnace slag from 10% to 50 % with an increment of 10%, and silica fume 10%. The chemical admixture (super plasticizer) is used at 0.5% by weight of cement in order to improve the properties of fresh concrete. The strength properties of hardened concrete include compressive strength of cube and cylinder, split tensile strength of cylinder, flexural strength of prism and stress strain behavior of cylinder. The results are compared with that of the conventional concrete. Based on the results of the experimental study some important conclusions have been drawn.

Keywords- strength of concrete, mineral and chemical admixtures, silica fume, fly ash, ggbs **1.**

1. INTRODUCTION

Admixtures are defined as a material other than water, aggregate, cement, used as an ingredient of concrete or mortar added to the batch immediately before or during mixing. Portland cement improves many qualities of concrete, such as: Lower the heat of hydration and thermal shrinkage and increase the water tightness.

Mineral admixtures are in organic material both natural and industrial by products that are added in small quantities in cements. Such additives may be blended or inter grounded with OPC or added directly to concrete before or during mixing.

Chemical admixtures are used to enhance the properties of concrete and mortar in the plastic and hardened state. These properties may be modified to increase compressive and flexural strength at all ages, decrease permeability and improve durability, inhibit corrosion, reduce shrinkage, accelerate or retard initial set, increase slump and workability, increase cement efficiency, and improve the economy of the mixture.

2. EXPERIMENTAL INVESTIGATION

2.1 ORDINARY PORTLAND CEMENT (OPC)

Cement is a binding material used in construction that sets, hardens, and adheres to other materials to bind them together. In this present study, Ordinary Portland Cement (OPC) of grade 43 is used for all concrete mixes. The specific gravity of cement is found as 3.15 and the standard consistency was 30%. The initial setting time was found to be 30 min and the final setting time was found to be 480 min. The cement used in this study is fresh and without any lumps.

2.2 FINE AGGREGATE

In this study, Bhavani River sand has been used as a fine aggregate. The sand was washed and screened at site to remove deleterious materials and tested as per the procedure given in IS: 2386-1968. Locally available river sand is confirmed to zone III of table 4 of IS 383– 1970 was used. The specific gravity of sand

is 2.6. For increased workability and for economy as reflected by use of less cement, the fine aggregate should have a rounded shape.

Table 2.2 Test on Fine aggregate

Properties	Value
Fineness modulus	2.62
Bulk density	1680 kg/m3
Water absorption	1.15%

2.3 COARSE AGGREGATE

Coarse aggregate used for this investigation is angular and is obtained from nearby quarry. The aggregate passing through 20 mm sieve and retained on 10 mm sieve is used to increase the strength. The specific gravity of coarse aggregate was found to be 2.60.

Table 2.3 Test on Coarse aggregate

Properties	Value
Fineness modulus	6.25
Bulk density	1660 kg/m^3
Water absorption	1.25%

2.4 FLY-ASH

Fly ash obtained from Mettur Thermal Power station was used in this investigation. This fly ash is classified as class F low calcium fly ash. The physical and chemical properties of fly ash is given in table 2.4

Table 2.4 Physical requirement of Fly Ash

S No	Characteristics	Requirements	
1	Fineness – specific surface in m^3 / kg	320 (min)	250 (min)
2	Lime reactivity – average compressive strength in N/ mm^2	4 (min)	3 (min)
3	Compressive strength @ 28 days in N/ mm^2	Not less than 80 % of the strength of PCC	
4	Drying shrinkage	0.15 %(max)	0.10 %(max)
5	Soundness	0.80 %(max)	0.80 %(max)

2.5 GROUND GRANULATED BLAST-FURNACE SLAG

Ground granulated blast-furnace slag was procured from Salem steel plant. The chemical properties of GGBS is given in table 2.5

Table 2.5 Chemical composition of GGBS

SL.NO	PROPERTIES	(%)
1	SiO_2	32.6
2	Al_2O_3	12.8
3	Fe_2O_3	1.3
4	CaO	41.0
5	MgO	7.2
6	Na_2O,K_2O	2.6
7	SO_3	0.03
8	LOI	0.2
9	Fineness	4000

2.6 SILICA FUME

Silica fume was procured from Coimbatore. The chemical properties of Silica fume is given in table 2.6

Table 2.6 Chemical composition and classification of silica fume

SL NO	Description	Typical Value
1	Silica(SiO_2)	88%
2	Aluminium(Al_2O_3)	0.22%
3	Iron Oxide(Fe_3O_3)	2.22%
4	Calcium Oxide(Cao)	0.7%
5	Magnesia Oxide(MgO)	0.78%

2.7 SUPER PLASTICIZERS

Hyper plasticizers carboxylate ether based super plasticizer were used as chemical admixtures in this investigation. The properties of hyper plasticizers is given in table 2.7

Table 2.7 The properties of Hyper Plasticizers

Sl no	Properties	Variables
1	Specific gravity	1.22-1.225
2	Chloride content	Nil (as per BS; 5075)
3	Recommended dosage	0.6 to 1.4 lit /100 kg of cement
4	Solid content	40%
5	Compatibility	Expect high alumina content
6	LOI	0.2
7	Fineness (cm^2/g)	4000

3. RESULT AND DISSCUSION

3.1 RESULTS OF COMPRESSIVE STRENGTH OF CUBES FOR COMBINED ADMIXTURE

The results of compressive strength of cubes are obtained and are presented in Table 3.1 The variation of compressive strength with respect to type of concrete cube made by using different combination of silica fume, fly ash, and GGBS replacement by weight of cement. Result shows that the mixes with the

different combination gives consistently higher strength than the normal concrete.

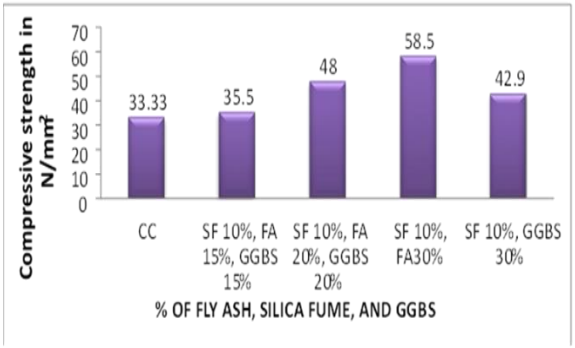

Fig.3.1 Cube Compressive Strength of Combined Admixtures

The figure 3.1 shows the cube compressive strength of SF 10% & FA 30% replaced by weight of cement is increased 75.5% when compared to the normal concrete.

Table 3.1 Cube Compressive Strength of Combined Admixtures

SL NO	Mix	Compressive Strength (N/mm^2)
1	Normal concrete (M30)	33.3
2	SF 10%, FA15%, & GGBS 15%	35.5
3	SF10%, FA 20%, & GGBS 20%	48.0
4	SF 10%, FA 30%	58.5
5	SF 10%, GGBS 30%	42.9

3.2 RESULTS OF SPLIT TENSILE STRENGTH OF CYLINDER FOR COMBINED ADMIXTURES

The results of Split Tensile Strength of cylinder are obtained and are presented in Table 3.2 The variation of Split Tensile Strength with respect to type of concrete cylinder made by using different combination of silica fume, fly ash, and GGBS replacement by weight of cement. Result shows that the mixes with the different combination gives consistently higher strength than the normal concrete.

Table 3.2 Split Tensile Strength of cylinder for Combined Admixture

SL NO	Mix	Split tensile strength (N/mm^2)
1	Normal concrete (M30)	3.39
2	SF 10%, FA15%, &GGBS 15%	3.8
3	SF10%, FA 20%, &GGBS 20%	4.5
4	SF 10%, FA 30%	4.8
5	SF 10%, GGBS 30%	4.2

The figure 3.2 shows the cube compressive strength of SF 10% & FA 30% replaced by weight of cement is increased 41.50 % when compared to the normal concrete

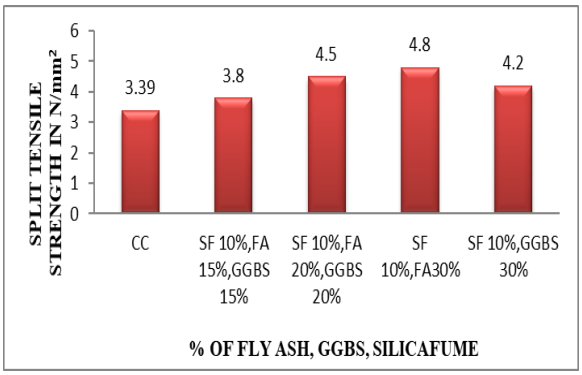

Fig.3.2 Split Tensile Strength of Combined Admixtures

3.3 RESULTS OF FLEXURAL STRENGTH OF PRISM FOR COMBINED ADMIXTURES

The results of flexural strength of prism are obtained and are presented in Table 3.3 The variation of flexural strength with respect to type of concrete prism made by using different combination of silica fume, fly ash, and GGBS replacement by weight of cement. Result shows that the mixes with the different combination gives consistently higher strength than the normal concrete.

Table 3.3 Flexural Strength of prism for Combined Admixture

SL NO	Mix	Flexural strength (N/mm^2)
1	Normal concrete (M30)	4.0
2	SF 10%,FA15%,&GGBS15%	4.2
3	SF10%,FA20%,&GGBS 20%	5.0
4	SF 10%, FA 30%	5.4
5	SF 10%, GGBS 30%	4.8

The figure 3.3 shows the Flexural Strength of SF 10% & FA 30% replaced by weight of cement is increased 35% when compared to the normal concrete

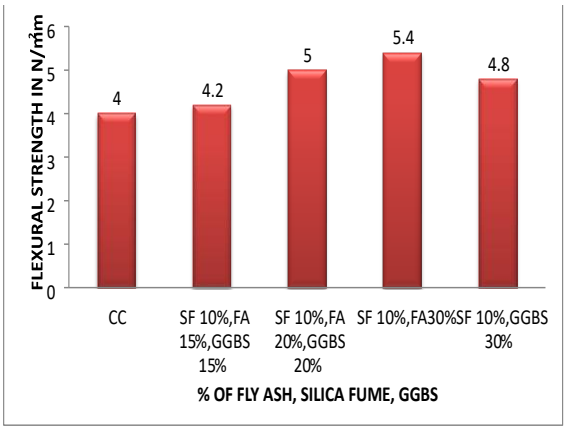

Fig.3.3 Flexural Strength of Combined Admixtures

3.4 RESULTS OF STRESS STRAIN BEHAVIOUR OF CYLINDER FOR CONVENTIONAL CONCRETE

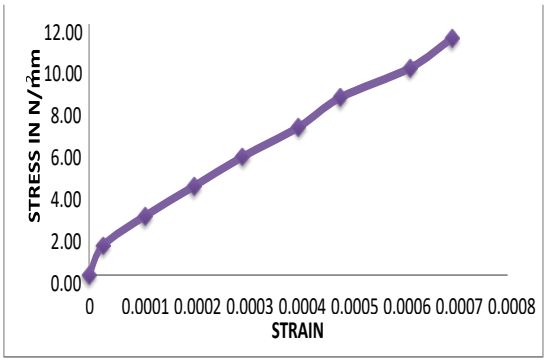

Fig 3.4 Stress strain behaviour of conventional concrete

3.5 RESULTS OF STRESS STRAIN BEHAVIOUR OF CYLINDER FOR SILICA FUME 10% IN CONCRETE

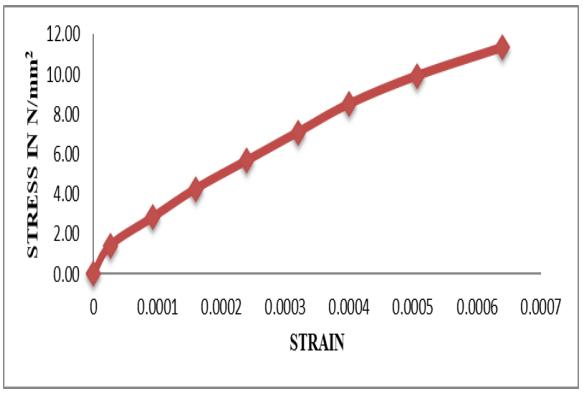

Fig 3.5 Stress strain behaviour of silica fume 10% in concrete

3.6 RESULTS OF STRESS STRAIN BEHAVIOUR OF CYLINDER FOR FLY ASH 20%, 30%, 40% & 50% IN CONCRETE

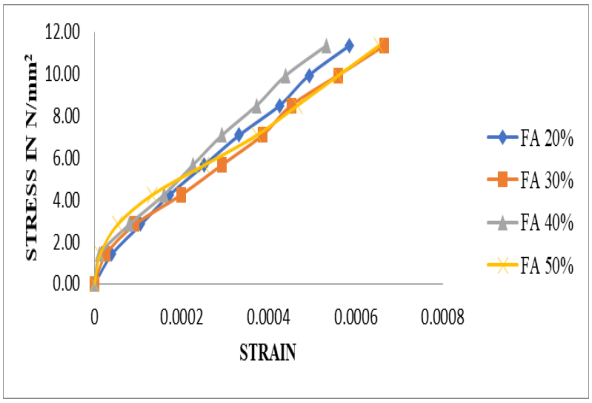

Fig 3.6 Stress strain behaviour of Fly Ash in concrete

3.7 RESULTS OF STRESS STRAIN BEHAVIOUR OF CYLINDER FOR GGBS 20%, 30%, 40% & 50% IN CONCRETE

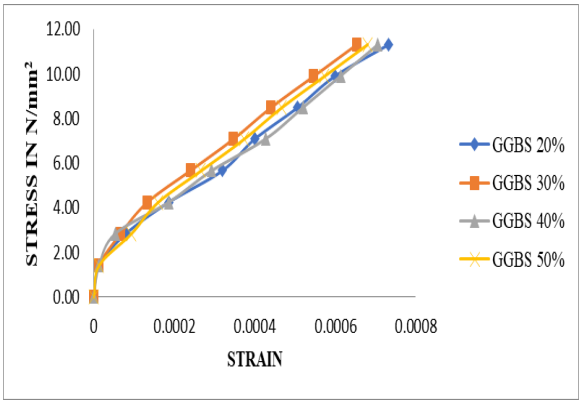

Fig 3.7 Stress strain behaviour of GGBS in concrete

3.8 RESULTS OF STRESS STRAIN BEHAVIOUR OF CYLINDER FOR COMBINED ADMIXTURES IN CONCRETE

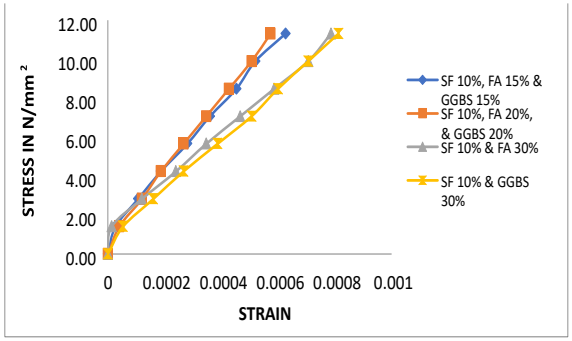

Fig 3.8 Stress strain behaviour of combined admixtures in concrete

4. CONCLUSION

1. An experimental study has been carried out find strength of concrete without mineral and chemical admixtures. The details of the experimental study are given in the previous chapter. Based on the experimental studies following conclusions are drawn.
2. It is to be observed that considerable increase in strength of concrete has been obtained by the addition of silica fume 10% in concrete when compared to that of the conventional concrete.
3. It is to be observed that 20% addition of fly ash in concrete gives the better strength properties of concrete than that of the conventional concrete.
4. It is to be observed that 20% addition of GGBS in concrete gives the better strength properties of concrete than that of the conventional concrete.
5. From the test results it is observed that the combination of SF 10% + FA 30% gives the better results when compared to the conventional concrete
6. Tri blended admixtures namely SF 10%+ FA 20%+ GGBS 20% gives the lower strength than that of the di blended admixtures.
7. The stress strain behaviour of the concrete with admixtures is similar to that of the conventional concrete.
8. When Silica Fume 10% & fly ash 30% replaced by weight of cement its offering a less water absorption compared to the normal concrete
9. When Silica Fume 10% & fly ash 30% replaced by weight of cement the its offering a very good resistance against sulphate effect compared to the normal concrete
10. When Silica Fume 10% & fly ash 30% replaced by weight of cement the its offering a very good resistance against chloride effect compared to the normal concrete
11. When Silica Fume 10% & fly ash 30% replaced by weight of cement the half-cell potential reading clearly shows that the admixture concrete offers much more resistance to the corrosion induced by the current. Results of weight loss after specified period of corrosion is comparatively less than that of the normal concrete. Hence it is concluded that the addition of combined admixtures offers a very good resistance against corrosion attack compared to the normal concrete

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