ANALYSIS OF FERROCEMENT USING GGBFS AND SILICA FUME

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Abstract - *Concrete engineering area is an area of research where GGBFS and Silica fume offers the opportunity to enhance the understanding of concrete behavior to engineer its properties. This paper presents experimental results on the compression, tension and flexural behavior of high performance concrete cubes, cylinders and beams with the addition of GGBFS and Silica fume. Twelve cubes, cylinders and beams specimen with 150 x 150, 150 x 300 and 150 x 150 x 600 mm cross section were cast from modified concrete. The test result indicated that the initial cracking and ultimate strength increased as the percentage of GGBFS and Silica fume increased. The aim of this study is to research the effect of adding GGBFS and Silica fume to high performance concrete under compression, tension and flexural behavior and find optimized percentage of adding GGBFS and Silica fume*

***Key Words*: Modified mortar[1], GGBFS[2], Silica fume[3], compression[4], tension[5], flexural strength[6].**

1. INTRODUCTION

Ferrocement is the composite of Ferro (Iron) and cement (cement mortar). Ferrocement can be considered as a type of thin walled reinforced concrete construction in which small-diameter wire meshes are used uniformly throughout the cross section instead of discretely placed reinforcing bars and in which Portland cement mortar is used. In ferrocement, wire-meshes are filled in with cement mortar. It is a composite, formed with closely knit wire mesh; tightly wound round skeletal steel and impregnated with cement mortar.

Ferrocement has a history of more than 170 years. The idea of impregnating closely spaced wire meshes with rich cement mortar is similar to the Kood type of age-old method of walling. In Kood system, bamboo and reeds are tied closely together and filled in with a mix of mud and cow dung as a matrix. It is used in rural areas of India. Hence ferrocement may be called as a modified form of Kood with standardized raw materials, systematic method of construction and reliable structural properties. Here the mesh is used in place of bamboo and reeds, and cement mortar instead of mud.

Ground granulated blast furnace slag is a recyclable material and is obtained by quenching molten slag from a blast furnace in water or stream to produce a glassy, granular product that is then dried and ground into a fine powder. Blast furnace slag is defined as the non metallic product essentially consisting of calcium silicates and other bases that is developed in molten condition simultaneously with iron in a blast furnace.

Silica fume, also known as micro silica is an amorphous (non-crystalline) polymorph of silicon dioxide. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production. It is extremely fine with particles size less than 1 micron and with an average diameter of about 0.1 microns, about 100 times smaller than average cement particles. Its behaviour is related to the high content of amorphous silica. The reduction of high-purity quartz to silicon at temperatures up to 2,000°C produces SiO_2 vapours, which oxidizes and condense in the low temperature zone to tiny particles consisting of non-crystalline silica.

Aim of the study:

The main aim of the study is to increase the strength of concrete adhesion between aggregate surfaces, cement paste because strength of these materials plays important role. However with the advancement in concrete technology and availability of GGBS material and silica fume, modified concrete can now be produced. Now a day's ferrocement technology has a great importance because of the results in significantly improved properties.

2. EXPERIMENTAL PROGRAME

Experimental work consists of addition of 10%, 20%, 30% of GGBFS and 5%, 10%, 15%, of silica fume by weight of cement to the concrete mixture, and comparison of it with normal control concrete. For this, M30 grade mix design was selected. In this work, the performance of concrete with addition of GGBFS and silica fume is investigated after 7 days of curing.

Detail of this set as follows:
SET-I: 0% addition of GGBFS and Silica fume
SET-II: 10% addition of GGBFS and 5% of Silica fume by weight of cement.
SET-III: 20% addition of GGBFS and 10% of Silica fume by weight of cement.

SET-IV: 30% addition of GGBFS and 15% of Silica fume by weight of cement.

Experimental Procedures:
Total 12 numbers having size 150 x300mm cylinder specimens for splitting tensile strength test, 12 numbers having size 150x150mm cubes for compressive strength test, 12 numbers having size 150x150x600 mm beams were casted for flexural test in the laboratory. After moulding at the age of 1 day, curing was done in water for 7 days & after 7 days tests were conducted.

Following test to be performed to check the ferroconcrete properties:

1) Compressive strength test
2) Split tensile strength test
3) Flexural strength test

1) Testing of cube specimens for compressive strength:
For the compression test, the cubes are placed in machine in such a manner that the load is applied on the face perpendicular to the direction of casting. In Compression testing Machine, the bottom surface of machine is fixed and load is applied on the top surface of specimen. The rate of loading is gradual and failure (crushing) load is noted. Also the failure pattern is observed precisely.
The compressive strength is calculated from the formula
Fc = P/A
Where, P = Load at failure, KN
A = Cross sectional area of cube (mm2)
Fc = Compressive Strength, Mpa

Fig.1 Compression testing machine

2) Testing of cylinder specimens for split tensile strength:
The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of a compression testing machine and the load is applied until failure of the cylinder, along the vertical diameter. The loading condition produces a high compressive stress immediately below the two generators to which the load is applied. But the larger portion corresponding to depth is subjected to a uniform tensile stress acting horizontally. It is estimated that the compressive stress is acting for about 1/6 depth and remaining 5/6 depth is subjected to tension.
The split tensile strength of cylinder is calculated by the following formula,
ft = 2P /3.14LD

Where,
ft = Tensile strength, MPa P = Load at failure, kN
L = Length of cylinder, mm
D = Diameter of cylinder, mm


Fig.2 Split tensile testing

3) Testing of beam specimen for Flexural test:
In flexure test, the beam specimen is placed in the machine in such a manner at the load is applied to the upper most surface as cast in the mould. All beams are tested under one-point loading in Universal Testing Machine of 100-tonne capacity. The load as increased until the specimen failed and the failure load is recorded. The adjoining shows the flexural strength test setup for the beam. Standard beams of size 150 x 150 x 600mm placed in the machine such that one point load is applied at distance l/2 from the support, till failure of the specimen. The deflection at the center of the beam is measured with sensitive dial gauge on UTM.
The flexural strength is determine by the formula,
fcr = PL/bd2

Where,
Pf = Central point through two point loading system, KN
L = Span of beam, mm
b = Width of beam, mm
d= Depth of beam, mm

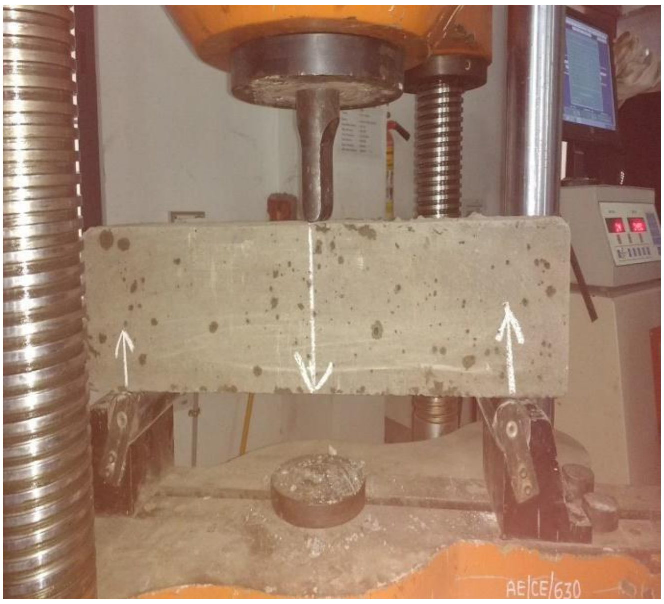


Fig.3 Flexural testing UTM

3. RESULTS AND DISCUSSION

1. Compressive strength test of PC sample:

Sr.No	Description of Specimen	Maximum Load(KN)	Compressive Strength(Mpa)	
1	PC	425	18.7	19.46
2	PC	434	19.5	
3	PC	448	20.2	

Table No.1

2. Compressive strength test of 10% GGBFS and 5% Silica fume sample:

Sr.No	Description of Specimen	Maximum Load(KN)	Compressive Strength(Mpa)	
1	Sample1	543	24.2	24.26
2	Sample2	538	23.8	
3	Sample3	558	24.8	

Table No.2

3. Compressive strength test of 20% GGBFS and 10% Silica fume sample:

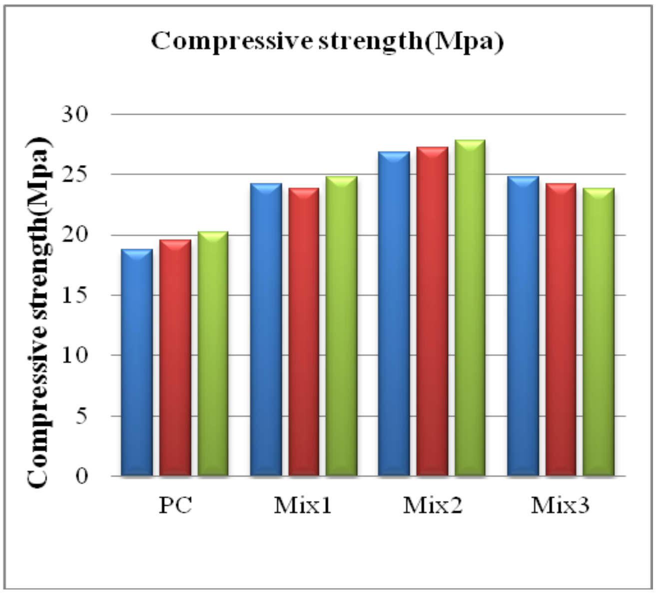
Sr.No	Description of specimen	Maximum Load(KN)	Compressive Strength(Mpa)	
1	Sample1	598	26.8	27.26
2	Sample2	618	27.2	
3	Sample3	627	27.8	

Table No.2

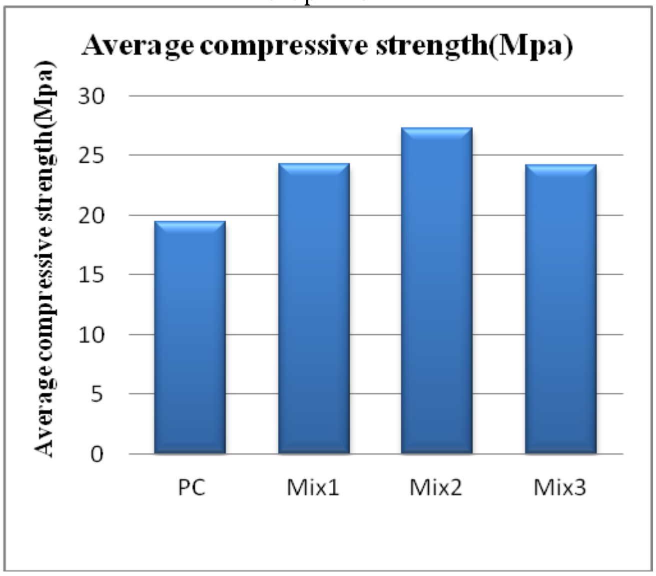
4. Compressive strength test of 30% GGBFS and 15% Silica fume sample:

Sr.No	Description of specimen	Maximum Load(KN)	Compressive Strength(Mpa)	
1	Sample1	553	24.8	24.26
2	Sample2	550	24.2	
3	Sample3	537	23.8	

Table No.4



Graph No.1



Graph No.2

The average compressive strength of PC was 19.46 MPa, Group Mix1 was 24.26 MPa. Group Mix2 was 27.26 MPa, Group Mix3 was 24.20MPa. The test result of compression strength shown in the table 1 to 4 and graph 1, 2, compressive strength developed in every case because of

GGBFS and Silica fume is higher than plain concrete specimen. It indicates the compressive strength of concrete specimen increase from 10% to 20% of GGBFS and 5% to 10% of Silica fume in concrete and for 30% of GGBFS and 15% of Silica fume it decrease. The maximum increase in average compression strength test is 40% as compared to control concrete.

1. Split tensile strength test of PC sample:

Sr. No	Description of Specimen	Maximum Load(KN)	Split tensile Strength (Mpa)	
1	PC	192	2.70	2.62
2	PC	188	2.68	
3	PC	178	2.50	

Table No.5

2. Split tensile strength test of 10% GGBFS and 5% Silica fume sample:

Sr.No	Description of Specimen	Maximum Load(KN)	Split tensile Strength(Mpa)	
1	Sample1	199	2.80	2.83
2	Sample2	200	2.85	
3	Sample3	201	2.84	

Table No.6

3. Split tensile strength test of 20% GGBFS and 10% Silica fume sample:

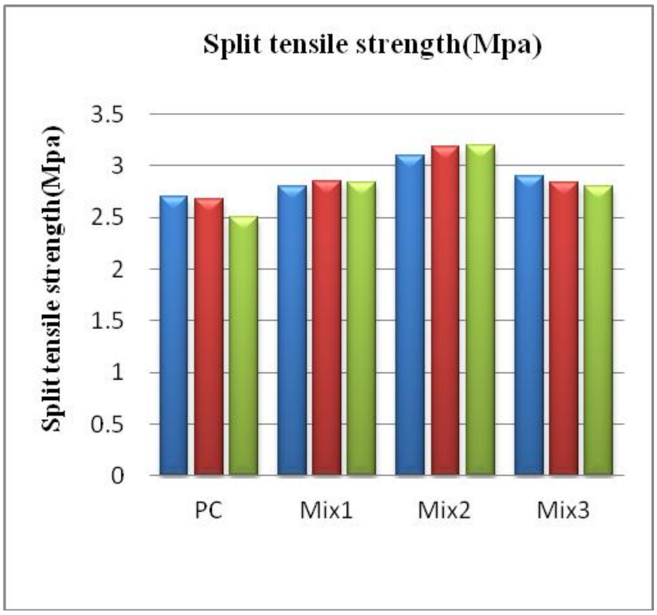
Sr.No	Description of Specimen	Maximum Load(KN)	Split tensile Strength(Mpa)	
1	Sample1	220	3.10	3.16
2	Sample2	224	3.18	
3	Sample3	229	3.20	

Table No.7

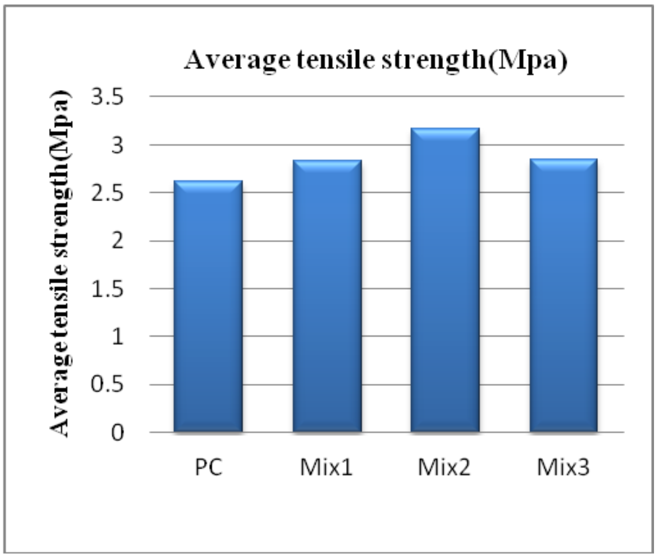
4. Split tensile strength test of 30% GGBFS and 15% Silica fume sample:

Sr.No	Description of specimen	Maximum Load(KN)	Split tensile Strength(Mpa)	
1	Sample1	207	2.90	2.84
2	Sample2	200	2.84	
3	Sample3	202	2.80	

Table No.8



Graph No.3



Graph No.4

The average split tensile strength of PC was 2.62 MPa, Group Mix1 was 2.83 Mpa, Group Mix2 was 316 MPa, and Group Mix3 was 2.84MPa. The test result of split tensile strength shown in the table 5 to 8 and graph 3, 4. Tensile strength developed in every case because of GGBFS and Silica fume is higher than plain concrete specimen. It indicates that the tensile strength of concrete specimen increase from 10% to 20% of GGBFS and 5% to 10% of Silica fume in concrete and for 30% of GGBFS and 15% of Silica fume it decrease. The maximum increase in average tensile strength test is 20.61% as compared to control concrete.

1. Flexural strength test of PC sample:

Sr.No	Description of Specimen	Maximum Load(KN)	Flexural Strength(Mpa)	
1	PC	15.06	3.12	3.23
2	PC	18.49	3.26	
3	PC	17.45	3.32	

Table No.9

2. Flexural strength test of 10% GGBFS and 5% Silica fume sample:

Sr.No	Description of Specimen	Maximum Load(KN)	Flexural Strength(Mpa)	
1	Sample1	16.41	3.40	3.46
2	Sample2	19.74	3.48	
3	Sample3	18.07	3.52	

Table No.10

3. Flexural strength test of 20% GGBFS and 10% Silica fume sample:

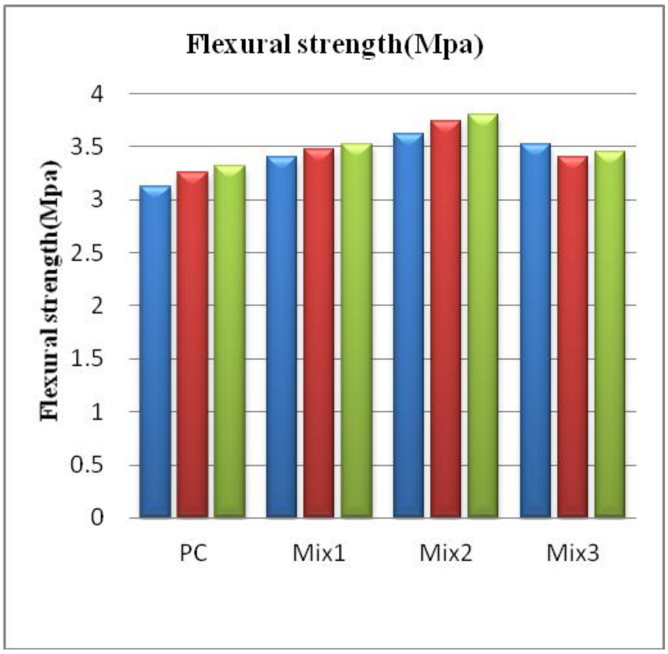
Sr.No	Description of Specimen	Maximum Load(KN)	Flexural Strength(Mpa)	
1	Sample1	17.47	3.62	3.72
2	Sample2	21.21	3.74	
3	Sample3	19.51	3.80	

Table No.11

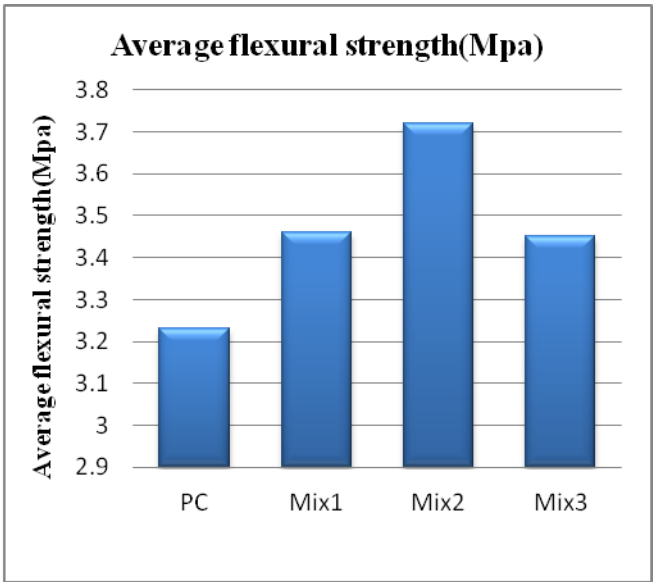
4. Flexural strength test of 30% GGBFS and 15% Silica fume sample:

Sr.No	Description of Specimen	Maximum Load(KN)	Flexural Strength(Mpa)	
1	Sample1	16.98	3.52	3.45
2	Sample2	19.28	3.40	
3	Sample3	17.71	3.45	

Table No.12



Graph No.5



Graph No.6

The average flexural strength of PC was 3.23 MPa, Group Mix1 was 3.46 Mpa, Group Mix2 was 3.72 MPa, and Group Mix3 was 3.45 MPa. The test result of flexural strength shown in the table 9 to 12 and graph 5, 6. Flexural strength developed in every case because of GGBFS and Silica fume is higher than plain concrete specimen. It indicates that the flexural strength of concrete specimen increase from 10% to 20% of GGBFS and 5% to 10% of Silica fume in concrete and for 30% of GGBFS and 15% of Silica fume it decrease. The maximum increase in average flexural strength test is 15.17% as compared to control concrete.

4. CONCLUSIONS

Following conclusions are drawn from the test result and values of strength calculated.

1. The compressive strength of concrete specimen increases from 10% to 20% of GGBFS and 5% to 10% of Silica fume in concrete and for 30% of GGBFS and 15% of Silica fume compressive strength decreases.
2. The maximum increase in average compressive strength test at 7 days is 40% as compared to PC sample
3. The split tensile strength of concrete specimen increases from 10% to 20% of GGBFS and 5% to 10% of Silica fume in concrete and for 30% of GGBFS and 15% of Silica fume split tensile strength decreases.
4. The maximum increase in average split tensile strength test is 20.61% as compared to PC sample
5. The flexural strength of concrete specimen increases from 10% to 20% of GGBFS and 5% to 10% of Silica fume in concrete and for 30% of GGBFS and 15% of Silica fume flexural strength decreases.
6. The maximum increase in average flexural strength test is 15.17% as compared to PC sample

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5. CONCLUSION

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