Comparison of Improvement in Compressive Strength of Concrete by Addition of Admixtures

S. M. Prasanna Kumar

Director
Rungta College of Engineering and
Technology
Bhilai, India
Email: prasanna@rungta.ac.in

Abstract: The feasibility of using industrial by products namely Ground Granulated Blast furnace Slag (GGBS) and Micro silica are used experimentally. The main objective of this work is to increase the use of GGBS, micro silica in construction industry. Also the particle sizes of admixtures have more influence on increase in strength of concrete because of their high surface area and amorphous nature. In this work the comparison is made between to admixtures and their effect on strength of concrete for different curing period. It is seen that surface area plays major role.

Keywords: Admixture, GGBS, MS, Particle size, Strength, surface area.

I. Introduction

There is no practically feasible alternative to conventional concrete composites, and the need for construction material concrete is bound to increase in spite of some of its shortcomings. The necessity of using admixtures to improve strength is alternative to reach the demand.

Admixtures: The use of admixtures in concrete is used extensively because of many benefits like surface area, reactive property and size. For instance, chemical admixtures can change the properties of cement paste by increasing the rate of hydration. Lessening the need of water are made by admixtures, can plasticize fresh concrete mixtures.

A. Ground Granulated Blast Furnace Slag (GGBS)

The molten slag obtained in furnace, as a secondary product of sintering of the raw materials granulates this new slag is obtained. The granulated slag at lesser size of 45 micron with a (Blaine) specific surface of 400-600 m^2/kg is called GGBS.

This slag is a glassy, non-metallic material containing mainly silicates and calcium oxide compounds. It has got both cementitious as well as pozzolanic properties.

B. Micro Silica MS

Micro Silica is obtained by the industry process in the silicon and ferrosilicon industry. The silicon material and ferrosilicon material having silicon contents upto 75%.

II. Material Characterization

A. Ground Granulated Blast Furnace Slag (GGBS)

GGBS is a glassy, granular, non-metallic admixture with silica and calcium oxide as main contents. Slag when powdered to a size 45 micron, will attain specific surface of about 400 to 600 m^2/kg. The SEM image (Fig. 1) of GGBS shows that the average particle size is around 5 microns and also the particles are more or less angular in shape. Fig. 2 shows the constituents of the chemicals by EDS. Table I and II shows Physical and chemical properties.

Table I: Shows Physical Properties of GGBS

Specific gravity	Bulk density(kg/m^3)	Surface area m^2/kg	Insoluble residue (%)	Loss on ignition (%)	Moisture content (%)
2.90	1230	414	0.15	0.18	0.14

Table II: Chemical Composition of Ggbs in Percentage

Binder	Sio_2	Cao	Al_2o_3	Mgo	Mno	Fe_2o_3	Sulphidesulphur	Sulphitesulphur	Total chlorides
GGBS	33.77	23.6	21.24	12.46	0.05	0.65	2.23	0.23	0.01

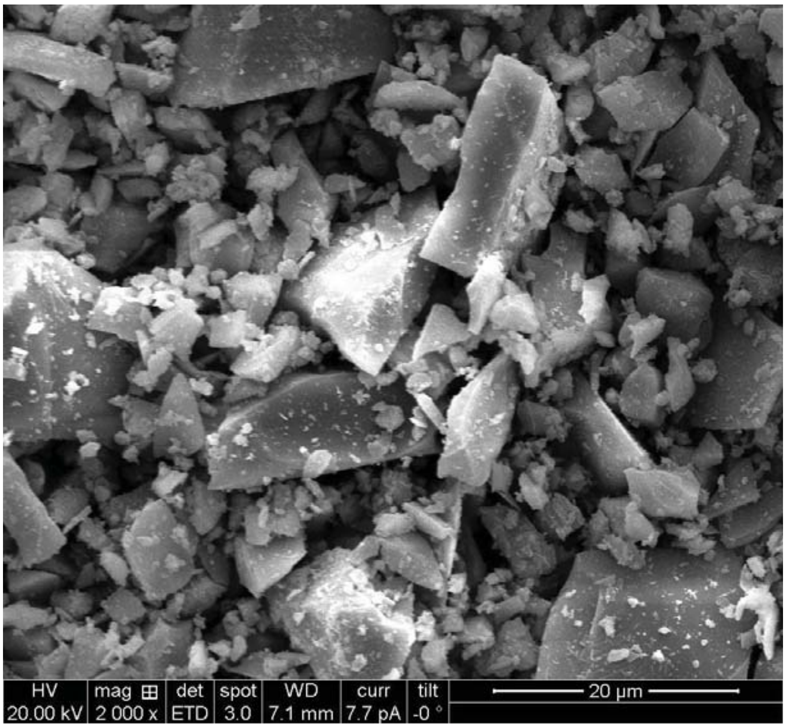

Fig. 1: SEM image of GGBS

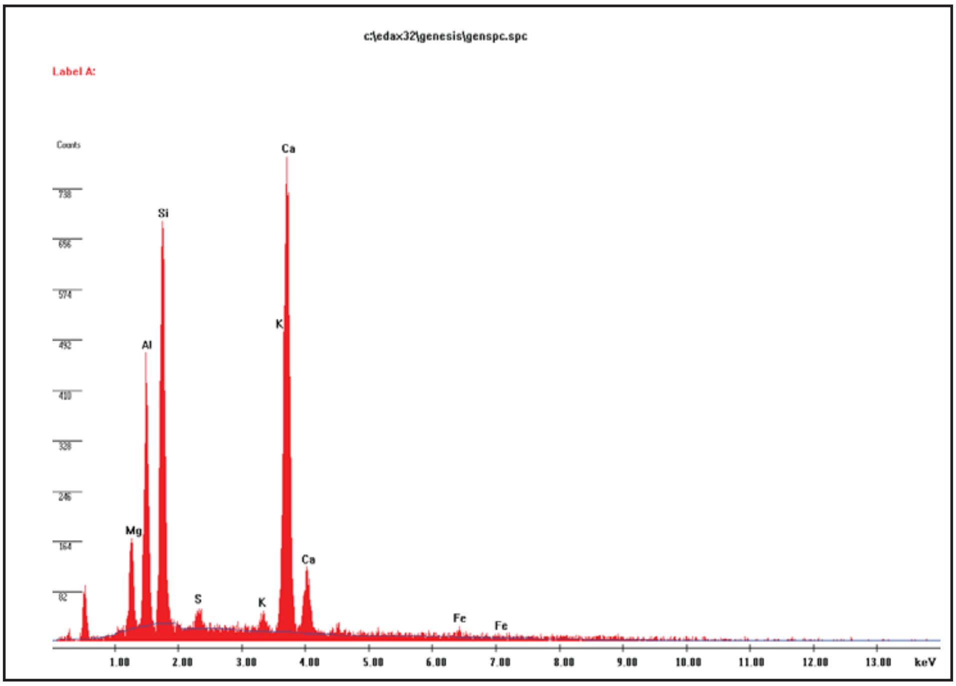

Fig. 2: Constituents of chemicals in GGBS

B. Micro Silica (MS)

MS has high surface area and has more reactive nature because of surface area. The physical and chemical properties of Micro Silica is as shown in Table III and IV.

Scanning electron microscope figure shows particle distribution and their sizes in Fig. 3. The EDS shows the different contents of elements in Fig. 4.

Table III: Shows Physical Properties of Micro Silica

Sl no	Chemical component	% by weight	% by weight
1	Sio_2	95%	99.97%
2	Sio_3	0.18%	-
3	Cl	0.12%	-
4	Total alkali	0.66%	-
5	Moisture content	0.16%	-
6	Loss of ignition	1.92%	0.67%
7	pH	7.9	4.1

Table IV: Chemical Properties

	Microsilica
Specific gravity	2.27
Surface area m^2/kg	2050
Particle size	<1micrometre
Bulk density kg/m^3	182
Loss on ignition (%)	1.92%
PH	7.70

Sl no	Chemical component	% by weight	% by weight
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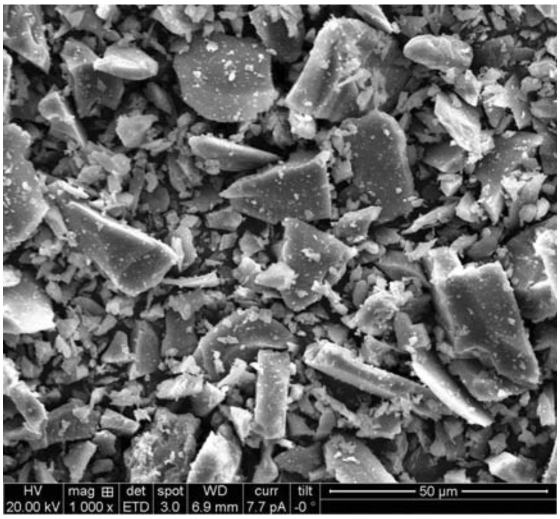

Fig. 3: SEM image of Micro Silica

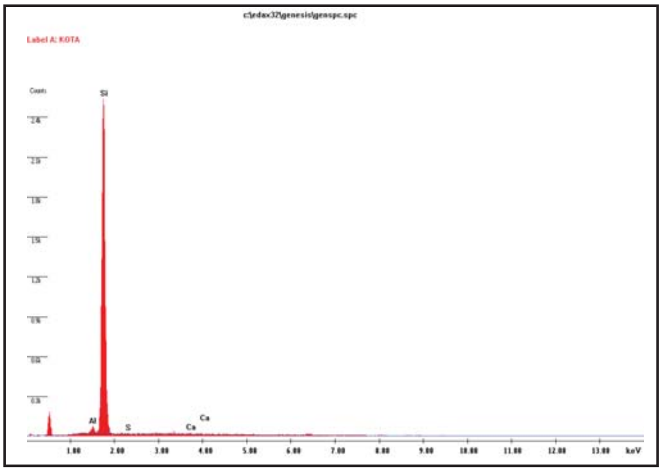

Fig. 4: Constituents of chemicals in Micro Silica

III. Compessive Strength of Concrete-Replacement of Cement With Mineral Admixures of Different Sizes

A. Results and Discussions

In this work results of experiments conducted to find the compressive strength of concrete matrix using additives MS and GGBS at different percentages and particle sizes are discussed.

B. Effect of 10% MS on Compressive Strength

Here 10% of cement by weight is replaced partially by micro silica, then the samples are investigated for compressive strength. Table V shows the effect of MS mixed to concreteat different sizes from 250 microns to 20 microns.

Also it is seen from the graph that, the % change between 7 days and 28 days is about 22%. It reveals that the lesser size of the particles of admixture caused the improvement in compressive strength. Strength is more in the case of 21 microns particles size, seen from the graph.

Fig. 5 shows the SEM texture after 10% addition and reaction.

Fig. 6 reveals the chemical constituents remained when 10% admixture is added.

Table V: Compressive Strength on Replacement of 10% of Ms

10% MS	250 Microns	125 Microns	90 Microns	45 Microns	20 Microns
7 Days	12.7	13.1	14.6	15.5	16.8
14 Days	13.7	15.6	17.2	19.4	20.2
21 Days	15.8	20.9	22.1	24.7	25.2
28 Days	17.9	22.3	24.6	26.5	27.5

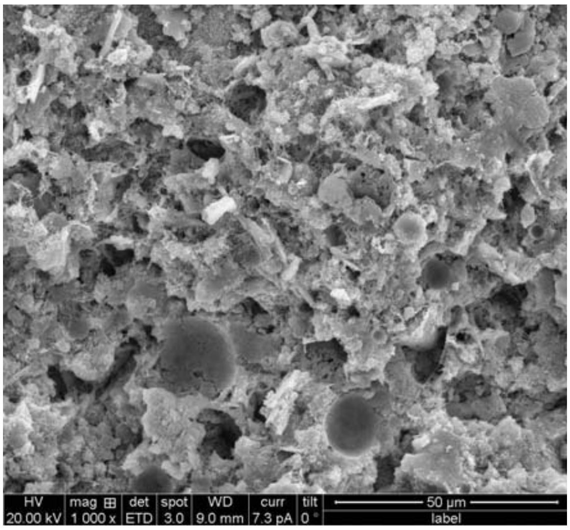

Fig. 5: SEM image of mix on addition 10% Micro Silica

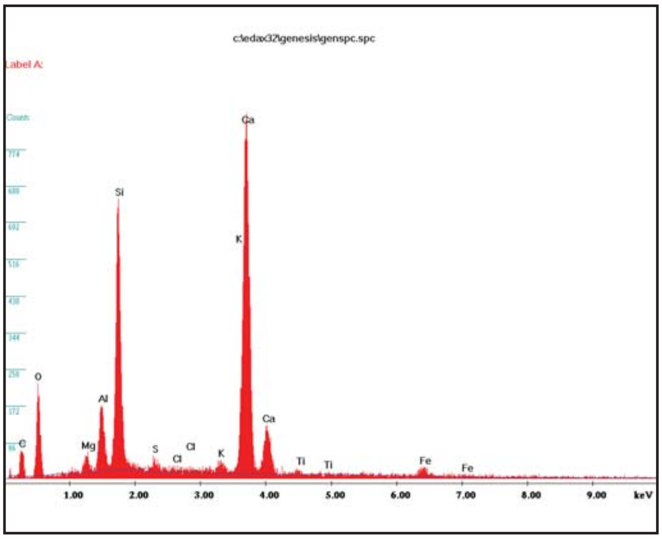

Fig. 6: Constituents of chemicals in mix for 10% addition of Micro Silica

C. Effect of 20% MS Compressive Strength

Here 20% of MS is mixed by reducing cement by weight. The samples were examined for compressive strength. Table VI shows the effect of different size particles varying from 250 microns to 21 microns is mentioned for different periods.

Fig. 7 shows the SEM data due to 20% addition and compounds seen after reaction.

Fig. 8 shows the chemical constituents remained after reaction when 20% admixture is added.

Table VI: Compressive Strength in Mpa on Replacement of 20% of Micro Silica

20% MS	250 Microns	125 Microns	90 Microns	45 Microns	21 Microns
7 Days	13.3	13.8	14.5	15.8	19.1
14 Days	15.2	16.4	17.8	19.5	21.6
21 Days	17.1	20.4	24.1	26.5	28.1
28 Days	18.7	21.3	25.6	28.4	30.9

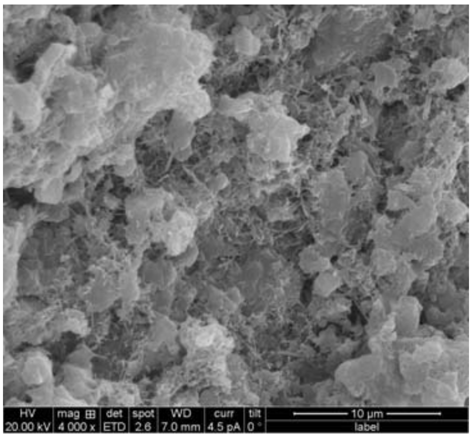

Fig. 7: SEM image of mix on addition 20% Micro Silica

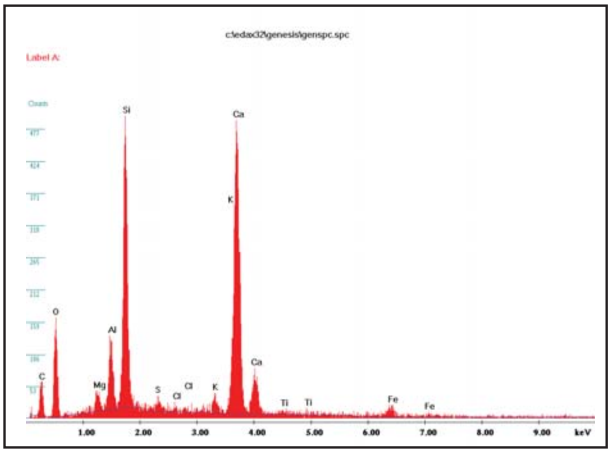

Fig. 8: Constituents of chemicals in mix for 20% addition of Micro Silica

D. Effect of GGBS on Compressive Strength

a. Effect of 10% GGBS on Compressive Strength

Here first 10% of cement is replaced with GGBS, the samples are tested for compressive strength at different days. Table VII shows the effect of GGBS on the compressive strength for different sizes differing from 250 to 20 microns.

Fig. 9 shows the SEM data due to 10% addition and compounds seen after reaction.

Fig. 10 shows the chemical constituents remained after reaction when 10% admixture GGBS is added.

Table VII: Compressive Strength on Addition of 10% of Ggbs

10% GGBS	250 Microns	125 Microns	90 Microns	45 Microns	20 Microns
7 Days	10.0	12.5	13.3	14.8	16.1
14 Days	11.5	13.2	14	15.6	16.1
21 Days	15.0	16.3	17.3	19.8	22.3
28 Days	18.0	19.0	21.30	22.0	25.4

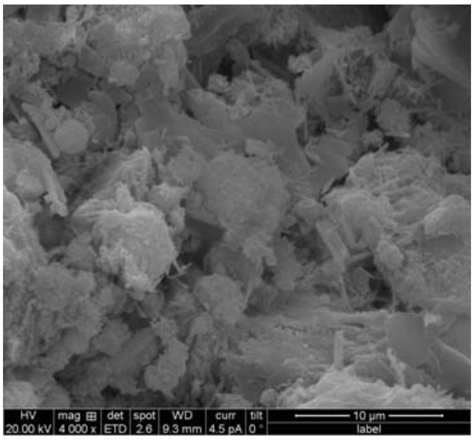

Fig. 9: SEM image of mix on addition 10% GGBS

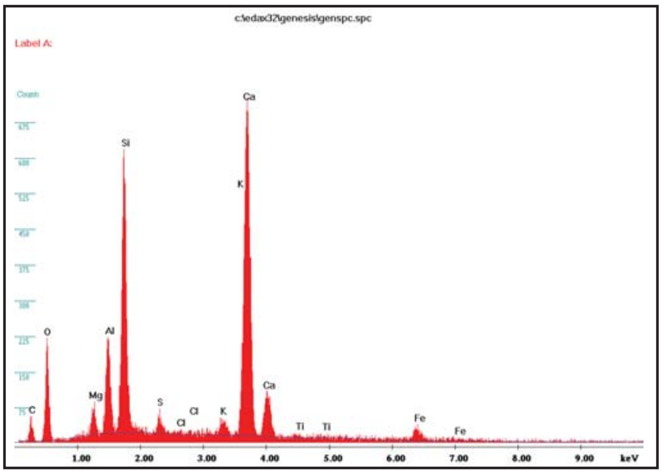

Fig. 10: Constituents of chemicals in mix for 10% addition of GGBS

b. Effect of 20% GGBS on Compressive Strength

The percentage change in strength seen from 7 days to 28 days is 37% for 20 microns size particles. The weekly based strength of the mix, there is a sudden increase in the strength from 14 days to 21 days about 20%. This reveals that calcium hydroxide ($Ca(OH)_2$) released after hydration process is reacting with silica (i.e. Sio_2) to form extra C-S-H gel and in turn gives strength to the concrete matrix. Table VIII shows Compressive strength on addition of 20% of GGBS.

Fig. 11 shows the SEM data due to 20% addition and compounds seen after reaction.

Fig. 12 shows the chemical constituents remained after reaction when 20% GGBS admixture is added.

Table VIII: Compressive Strength in Mpa on Addition of 20% of Ggbs

20% GGBS	250 Microns	125 Microns	90 Microns	45 Microns	20 Microns
7 Days	12.0	13.2	14.1	15.8	16.2
14 Days	12.3	13.9	16.1	17.5	20.5
21 Days	17.4	19.3	21.2	23.0	25.0
28 Days	22.9	23.1	24.7	25.2	26.1

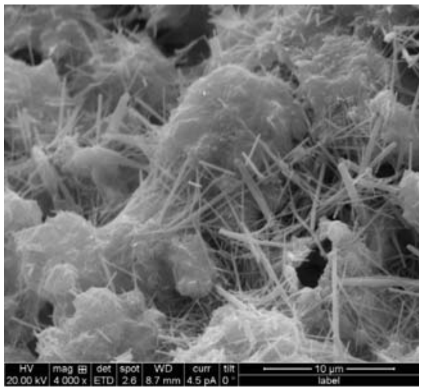

Fig. 11: SEM image of mix on addition 20% GGBS

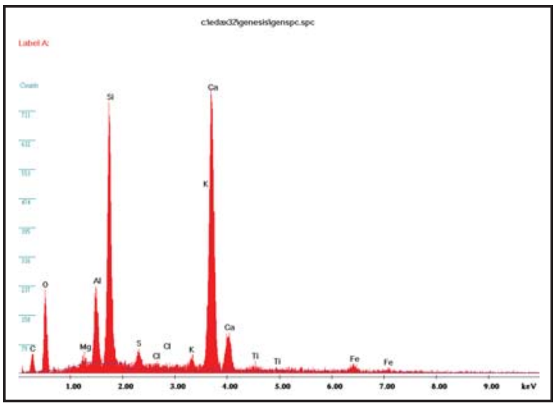

Fig. 12: Constituents of chemicals in mix for 20% addition of GGBS

Summary

Use of admixtures from industry by products is helping to improve the compressive strength of concrete mix.

Observed that 20% addition of Micro silica revealed in increasing compressive strength when compared to 20% addition of GGBS admixture.

Calcium Hydroxide released at the time of Hydration process is effectively utilized by Silica content added through admixtures are seen in SEM and Chemical compositions after reactions for both Micro Silica and GGBS. Hence leaching problem and voids in concrete mix can be reduced.

Improvement of 27% increase in compressive strength of concrete in case of 20% addition of Micro silica is observed. This would be due to surface area of admixture.

And dense material packing is seen in SEM which may be due to occupation finer particles in the micro gap present in the mix.

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