International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 09, September-2015

Comparison of Mechanical Properties of High Strength Concrete with Different Mineral Admixtures & Fine Aggregates

K. Divya Haritha
Ex-Sr. Engineer
L&T Construction, Hyderaba
Hyderabad, Telangana, India

R. Srujana
Associate Professor,
JNTU Hyderabad,
Telangana,India,

***Abstract* - This paper deals with the study of strength behaviour of Mineral admixtures, super plasticizer and chemicals on High strength concrete. Cement is replaced by 15 to 20% of fly ash or GGBS & Silica fume by volume of concrete, thus resulting in increase in strength, super plasticizer is added to increase the workability of concrete. Mechanical properties like compressive strength, split tensile strength and flexural strength of High strength concrete are compared by varying the Mineral admixtures in the Design mix. All the experimental work carried out for finding the aforementioned properties is in accordance with the corresponding Indian standard codes. Results reveal that the compression, split tensile, Flexural strength & Workability values of High strength concrete mixes with Flyash, GGBS & silica Fume are higher than the corresponding values of Conventional concrete. Also there is a slight increase in the above mentioned values when Fine aggregate is completely replaced by Crushed Rock Fine without changing cement content.**

Key words: High strength concrete; Compressive strength; Split tensile strength; Flexural strength

1. INTRODUCTION

Use of high strength concrete (HSC) has become more prevalent over normal-strength concrete (NSC) by using supplementary cementing materials such as silica fume (SF), Flyash, Ground granulated blast furnace slag (GGBS) and water reducing admixtures.

Some of the reasons are as follows:

1. To put the structure in to service at much earlier age, such as opening the pavement at third day
2. To build high- rise buildings by optimising column sizes and increasing available space
3. To build the super structures of long- span bridges and to enhance the durability of bridge Decks

The admixtures used in this Experimental study are as follows:

a) *Flyash*: Fly ash particles are in general spherical in shape and range in size from 0.5µm to 100µm. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous and crystalline), aluminium oxide (Al_2O_3) and calcium oxide (CaO). It is in general highly heterogeneous, consisting of glassy particles with various exacting crystalline phases such as quartz and various iron oxides. It reacts with the calcium hydroxide (lime) which is a by-product produced during cement hydration.

b) GGBS: Ground granulated blast-furnace slag is a non-metallic product consisting essentially of silicates aluminates of calcium and other bases. The molten slag is rapidly chilled by quenching in water to form a glassy sand like granulated material. The granulated material when further ground to less than 45 micron. The performance of slag largely depends on the chemical composition, glass content and fineness of grinding.

c) Silica fume: It is also referred to as micro silica or condensed silica fume. It is a product resulting from reduction of high purity quartz with coal in an electric arc furnace in the manufacture of silicon or ferrosilicon alloy. Silica fume rises as an oxidised vapour. It cools, condenses and is collected in cloth bags. It is further processed to remove impurities and to control particle size. It is spherical in shape.

d) *Super plasticizer:* They are also known as high range water reduces are chemicals used as admixtures where well-dispersed particle suspension is required. These polymers are used as dispersants to avoid particle aggregation and to improve the flow characteristics of suspensions such as in concrete application, in this experimental study GleniumB223 is used as Super plasticizer.

1.1 Scope of Experimental work :

The Present Experimental work mainly focussed on following issues:

1. To conduct feasibility study of producing high strength concrete using super plasticiser with fly ash, silica fume, GGBS, CRF Material.
2. To evaluate the workability characteristics in terms of compaction factor and slump test addition of fly ash, silica fume, and chemicals.
3. This experimental study is mainly focused on comparing the mechanical properties such as compressive strength, split tensile strength & Flexural strength with varying the

Mineral admixtures such as Flyash, GGBS & also replacing the Fine aggregate with crushed rock fine.
This research work was carried out at Jawaharlal Nehru Technological University, Hyderabad during December 2012 to May 2013.

2. MATERIALS AND METHODS:

The Raw materials used for this experimental work are as follows:

2.1 Aggregate:

Locally available natural sand with 4.75 mm maximum size in dried condition, Crushed Rock Fine material was used as fine aggregate and angular shaped Coarse aggregate with a maximum size of 20 mm, 12.5mm were used. Following are some test results of the aggregate [1].

Table1: Properties of Aggregate

Property	Fine Aggregate	Coarse aggregate
Specific Gravity	2.6	2.74
Fineness Modulus	2.73	-
Water Absorption	-	2%
Surface Texture	Smooth	-
Particle Shape	-	Angular

2.2 Cement:

In this experimental study, Ordinary Portland Cement (OPC) conforming to IS 12269: 1987 [2] was used. The properties of the cement used are shown in Table2

Table 2: Properties of Cement

Test Conducted	Description	Test Result
Specific Gravity	Obtained using Specific Gravity Bottle [3]	3
Initial Setting Time	Obtained using Vicat apparatus as per IS 4031(Part5):1988 [4]	45 minutes
Fineness	Obtained using Blaine Apparatus (sq.m/kg) [5]	225

2.3 Mix proportioning:

Table 3 shows the various trial mixes which are casted to arrive at a design mix of High strength Concrete.

Table 3: Trial Design Mixes

Trial Mix	DM-A	DM-B	DM-C
Material	Kg/m^3	Kg/m^3	Kg/m^3
OPC	429.25	420	474
Flyash	50.5	45.5	45
GGBS	25.5	21.23	45
Silicafume	0	21.23	0
Sand	755	755	752
10-12 mm	607.6	607.6	605.7
20mm	405.0	405.0	403.8
Glenium	7.7	7..7	7.7
Water	161.5	158	158
Total	2441.9	2433.6	2491.3
w/c ratio	0.33	0.32	0.28

Note: In the above table "DM" refers to Design Mix
Cubes of 10cm size of all the above mentioned design mixes are casted and subjected to accelerated curing. Based on the compressive strength values obtained after testing, the Design Mix-C is chosen for which the mechanical properties are found out by varying the Mineral Admixtures and by replacing the Fine aggregate with Crushed rock fine.

2.4 Mix Design for High strength Concrete:

Table 4: Design Mixes of High strength concrete

Design Mixes	DM-1	DM-2	DM-3
Material	Kg/m^3	Kg/m^3	Kg/m^3
OPC	474	474	474
Flyash	45	0	45
GGBS	0	45	0
Silicafume	45	45	45
Sand	752	752	0
CRF	0	0	752
10-12 mm	605.7	605.7	605.7
20mm	403.8	403.8	403.8
Glenium	7.7	7.7	7.7
Water	158	158	158
w/c ratio	0.28	0.28	0.28

Note: In the above table "DM" refers to Design Mix

In Design Mix-1 CRF & GGBS are completely avoided whereas in Design Mix-2 GGBS is used in combination with sand as fine aggregate and finally in Design Mix-3 Flyash & Silicafume are added as Mineral admixtures & Sand is completely replaced by Crushed Rock Fine.

2.5 Experimental Methods:

The mixing, casting, de-moulding, curing, and testing concrete were carried out as per IS 516:1959 [6] All the specimens are demoulded after 24 Hours of casting and these specimens are cured by wet covering under controlled conditions. The specimens which are taken out of curing are immediately tested, after taking out surplus water, at various ages as per the requirements of each test. In contrast. The cubes of 10 cm size are tested for compressive strength as per IS 516:1959. For split tensile strength testing, the cylinders of 10cm diameter and 20cm height are tested as per IS 5816: 1999[7]. The Flexural strength testing is carried out on a prism of 10cmx10cm cross section and 50cm longitudinal length, the test is conducted in accordance with IS 516: 1959. All the tests have been conducted on minimum three samples.

The slump test is conducted on an apparatus consisting of a metallic mould in the form of a frustum of a cone having diameter of 10cm at top, 20cm at bottom & 30cm height in which the freshly mixed concrete is filled in three layers each of 10cm height. After each layer is filled few tapping or blows by tamping rod are given.

The compacted factor test apparatus consists of two hoppers, each in the shape of frustum of a cone and one cylinder. The upper hopper is filled with concrete this being placed gently so that no work is done on the concrete at this stage to produce compaction. The concrete is allowed to fall in to the lower hopper by opening the trap door and then in to the cylinder mould placed at the bottom. Excess concrete across the top of the cylinder mould is cut and the net weight of the concrete in cylinder determined. This gives the weight of partially compacted concrete. Then the cylinder mould is filled with concrete in layers of 5cm depth by compacting each layer fully. The fully compacted weight is determined and compaction factor (C.F) is calculated as below

$$\text{C.F.} = \frac{\text{Weight of partially compacted concrete}}{\text{Weight of fully compacted concrete}}$$

3. RESULTS AND DISCUSSIONS:

3.1 Compressive Strength:

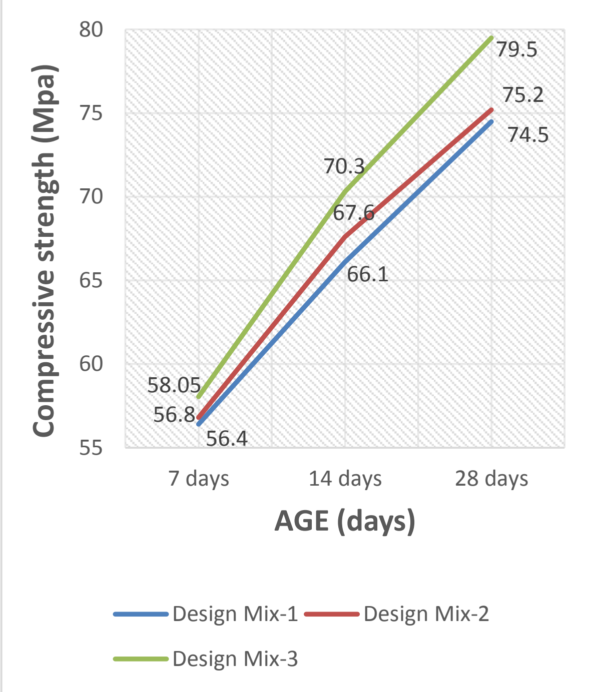

Figure 1: Comparison of compressive strength at various ages

Figure 2: Cubes casted for Compression test

As observed, 28-Day Strengths of Design Mix – 1, 2 & 3 are obtained as 74.5 MPa, 75.5 MPa and 79.5 MPa respectively. It is clearly seen that the compressive strengths of Concrete in which Crushed rock fine is used is higher than that of concrete in which sand is used as fine aggregate also the concrete with GGBS produced better strength than Flyash.

3.2 Split tensile strength test:

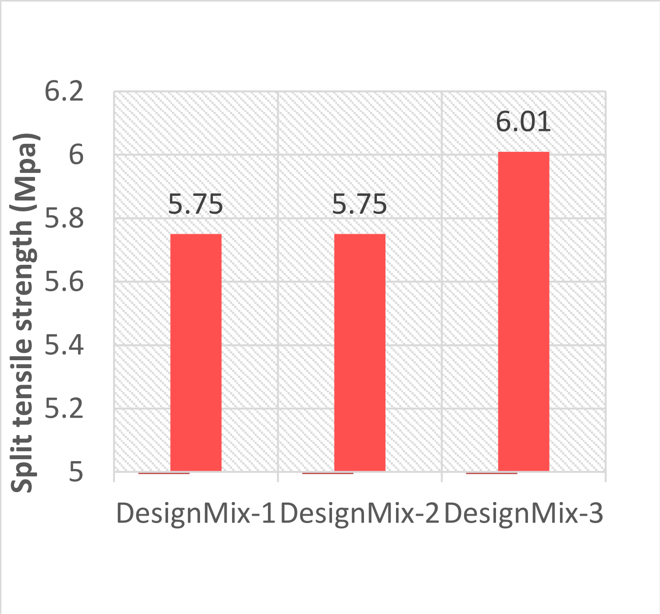

Figure 3: Comparison of split tensile strength at 28-day

Figure 4: Specimen after Split tensile testing

The split tensile strength value for Design Mix-3 is found to be higher than that of Design Mix-1&2 which shows that the tensile strength of Concrete will be increased when Fine aggregate is replaced with CRF. This may be attributed to the higher compressive strength of Design Mix-3. It should be noted that the split tensile strength test is an indirect way of finding the tensile strength of a concrete specimen (cylinder) subjected to compressive loading.

3.3 Flexural Strength Test:

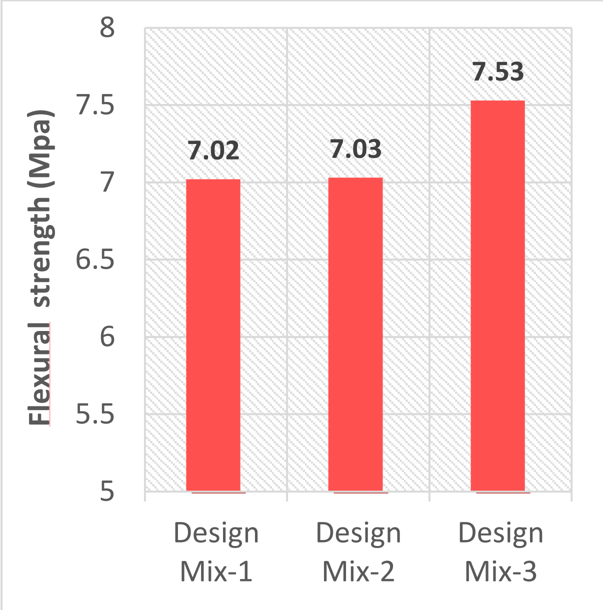

Figure 5: Comparison of Flexural strength at 28 day

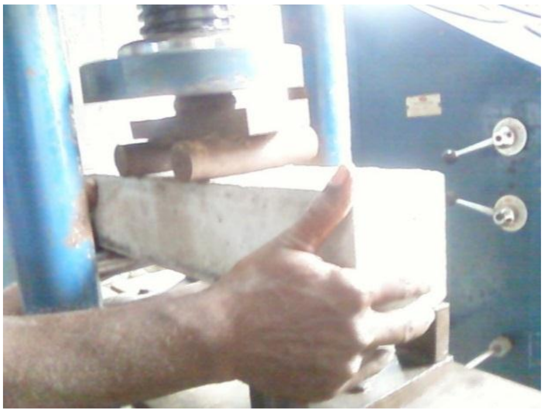

Figure 6: Flexural strength testing of a beam

Results reveal that the Flexural strength value is higher for the concrete in which Crushed rock fine is used when compared for the concrete with Mineral admixtures along with conventional Fine aggregate, It is also noted that the when GGBS is used instead of Flyash there is a slight increase in Flexural strength.

3.4 Workability :

The results arriving from Slump cone test and compaction factor test reveal that there will be no change when Flyash is replaced by GGBS as Mineral admixture but it increases when the Fine aggregate is completely replaced by Crushed rock fine.

Table 5: Workability of Design Mixes-1, 2 & 3

Workability		
Mix Type	slump (mm)	Compacting factor
Design Mix-1	70	0.94
Design Mix-2	70	0.94
Design Mix-3	75	0.95

4. CONCLUSIONS:

This is a typical research work serving the agenda of sustainable development and this is the High strength concrete for future generations who may get stuck to meet their needs for fine aggregate due to the depletion of natural resources by present generations. Also effort has been made to decrease the usage of cement content thus regulating the cost of concrete. The following conclusion can be drawn from the comparative studies made on the mechanical properties of conventional concrete with different mineral admixtures & also completely replacing the fine aggregate by crushed rock fine.

1. The performance of concrete with crushed rock fine as fine aggregate in compression test is better than that of the concrete with conventional fine aggregate, the concrete with GGBS resulted in slightly higher strength when compared with that of concrete with Flyash.
2. The spilt tensile strength of concrete is increased when Fine aggregate is completely replaced with crushed rock fine.
3. The Flexural strength results are also similar to that of Split tensile strength results as the concrete with crushed rock fine aggregate showed a better strength than conventional aggregate.
4. Workability tests using slump cone & Vee-Bee consistometer reveal that there is a slight increase in workability when crushed rock fine is used in concrete.

ACKNOWLEDGEMENT:

The authors thankfully acknowledge the guidance and technical knowledge imparted by Dr. M.V.Seshagiri Rao, in successfully accomplishing this research work.
The authors would also like to thank S.Satyasirisha, M.Sandeep & Nagarjuna for extending their kind support throughout the research work.

REFERENCES:

[1] IS 2386: 1963 (Part 3) Method of test for aggregate for concrete
[2] IS 12269: 1987 Specification for 53 Grade for Ordinary Portland Cement
[3] IS 4031(Part 11):1988 Methods of Physical tests for Hydraulic Cements : Determination of Density (First revision)
[4] IS 4031(Part 5):1988 Methods of Physical tests for Hydraulic Cements : Determination of initial and final setting times (First revision)
[5] IS 4031(Part 1):1988 Methods of Physical tests for Hydraulic Cements : Determination of fineness by Dry sieving (Second revision)
[6] IS 516:1959 (Reaffirmed 1999), Edition 1.2(1991-07) - Method of Test for Strength of Concrete
[7] IS 5816: 1999 Method of test for splitting tensile strength of Concrete