Study and Investigation of High Strength Concrete using Fly Ash, and Ground Granulated Blast Furnace with Various Materials

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ABSTRACT

Concrete is generally classified as Normal strength concrete, high strength concrete and ultrahigh strength concrete. High strength label was adopted to concrete having strength 50Mpa and above. In particular construction of high-rise buildings and long span bridges, concrete strengths of 90 to 120Mpa are occasionally used. High performance concrete is used for concrete mixture which posses high workability, high strength, high modulus of elasticity, high density, high dimensional stability and resistance to chemical attack. A substantial reduction of quantity of mixing of water is the fundamental step for making HPC. Adopting W/C ratio in the range of 0.25 to 0.3 and getting high slump is possible only with the use of super plasticizer. The use of appropriate super plasticizer is a key material for making HPC. In this project the effects of fly ash, ground granulated blast furnace slag, in M-50 grade concrete with different material proportions are studied for compressive, split tensile and flexural strengths.With constant percentages of Fly Ash and different percentage of GGBS of 5%, 10% and 15% with 1% of super plasticizer are used then the compressive strength, flexure strength and split tensile strength values are decreased by increasing the GGBS%.

I. INTRODUCTION

Concrete is generally classified as Normal strength concrete, high strength concrete and ultra high strength concrete.High strength label was adapted to concrete having strength above 50 Mpa.In particular construction of high-rise buildings and long span bridges, concrete strengths of 90 to 120Mpaare occasionally used.The advantage of prestressed concrete technology techniques has given impetus for making concrete of high strength. The manufacture of high strength concrete will grow to find its due place in concrete construction for all obvious benefits. In the modern batching plants high strength concrete produced in a mechanical manner. One has to take care about mix proportioning, shape of aggregate use of supplementary cementations materials and super plasticizer. With the modern equipment's production of high strength concrete has become a routine matter.High performance concrete is used for concrete mixture which possesses high workability, high strength, high modulus of elasticity, high density, high dimensional stability and resistance to chemical attack. High performance concrete is also a high strength concrete but it has a few more attributes specially designed as mentioned above.Admixture is defined as a material, other than cement, water and aggregate that is used as an ingredient of concrete and is added to the batch immediately before or during the mixing. Admixture is used to modify the properties of ordinary concrete so as to make it more suitable for any situation.

High strength concrete is necessary for prestress concrete as the material offers highly resistance in tension, shear bond and bearing. The use of high strength concrete results in a reduction in a cross sectional dimensions of prestress concrete structural element with a reduced dead weight of the material longer span become technically and economically practicable.

II. EXPERIMENTAL INVESTIGATION

The experimental investigation work is divided into three series as A, B&C.The first series i.e.… "A" indicates M-50 grade of concrete with Mix proportion 1: 1.0012: 3.004 with water cement ratio 0.32. In this phase of work cement is replaced with fly ash and Ground granulated blast furnace slag (GGBS) material for different proportions. For this, 09 cubes, 06 cylinders and 06 prisms are cast and tested under compression and flexural testing machine.

- A_1: [C + 5% FLY ASH+05% GGBS] + F.A + C.A + 1.0% S.P
- A_2: [C + 5% FLY ASH+10% GGBS] + F.A + C.A + 1.0% S.P
- A_3: [C + 5% FLY ASH+15% GGBS] + F.A + C.A + 1.0% S.P

Where in

A_1 indicates: Cement is 90%, Fly Ash is 5% &Ggbs is 5% with 1.0% Super plasticizer.

A_2 indicates: Cement is 85%, Fly Ash is 5% &Ggbs is 10% with 1.0% Super plasticizer.

A_3 indicates: Cement is 80%, Fly Ash is 5% &Ggbs is 15% with 1.0% Super plasticizer.

The dimensions of the moulds for casting cubes, cylinders and prisms are 100mm x 100mm x 100mm, 300mm x 150mm & 600mm x 100mm x 100mm respectively are used. The casting was done on a smooth floor. All the moulds are applied lubricant before concreting. After a day of casting moulds are de-moulded and then cubes, prisms & cylinders are moved to the curing tank carefully for curing.

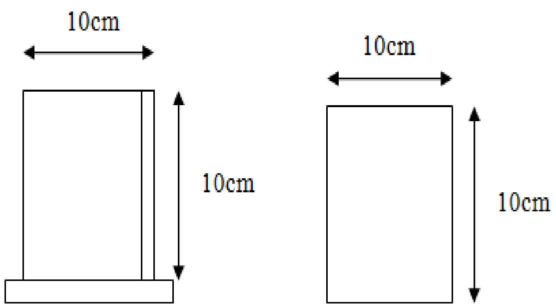

Figure 1: Cross section & top plan details of the cube

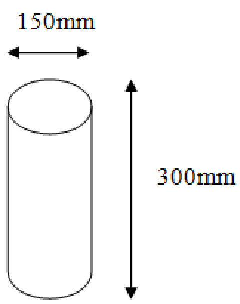

Figure 2: Cross sectional details of the cylinder

2.1 MATERIALS

The constituent materials and their physical properties are given below:

1. Cement

2. Coarse aggregate
3. Fine aggregate
4. Ground granulated blast furnace slag
5. Fly ash

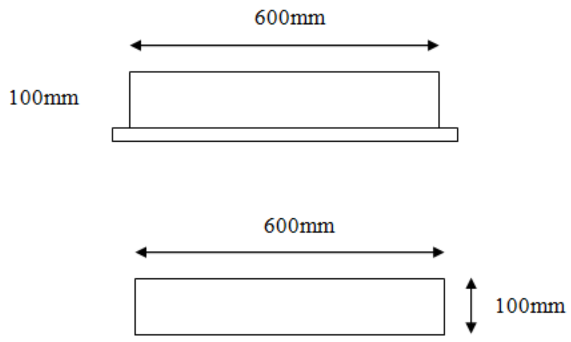

Figure 3: Cross sectional details of the prism

2.2MIX DESIGN

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible.The main objects of concrete mix design are

- To achieve the stipulated minimum strength and durability.
- To make the concrete in the most economical manner.

Design of concrete mix requires complete knowledge of the various properties of the constituent materials, the implication in case of change on these conditions at the site, the impact of properties of plastic concrete on the hardened concrete and complicated inter-relationship between the variables.

For low and medium strength concrete, the strength is mainly influenced by the water cement ratio, and is almost independent of the other parameters. The properties of high strength concretes with a compressive strength above 26.66 Mpa, are influenced by the properties of aggregate and aggregate cement ratio in addition to that of the water cement ratio.

In this project Entry and Shack lock's method are adopted which is an easy and accurate method for high strength concrete mixes. For purpose of design, Entry and Shack lock have suggested empirical graphs relating compressive strength to an arbitrary "Reference number" for concretes made with crushed granite coarse aggregate and irregular gravel.

2.3 PROCESS OF MANUFACTURE OF CONCRETE

2.3.1 BATCHING

The measurement of materials for making concrete is known as Batching

2.3.2 WEIGH BATCHING

Weigh is the correct method of measuring the material. Use of weight system is batching, facilitates accuracy, flexibility and simplicity. Different types of weigh batches are available. In smaller works, the weighing arrangement consists of two weighing buckets, each connected through a system of levers to spring loaded dials which indicate the load. The weighing buckets are mounted on a central spindle about which they rotate. Thus one can be loaded while the other is being discharged into the mixer skip. A simple spring and electronic balance or the common platform weighing machines also can be used for small job

Measurement of Water

When weigh batching is adopted, the measurement of water must be done accurately. Addition of water by graduated bucket in terms of liters will not be accurate enough for the reason of spillage of water etc. It is usual to have the water measured in a horizontal tank or a vertical tank fitted to the mixer.

2.3.3 MIXING

Through mixing of the material is essential for the production of uniform concrete. The mixing should ensure that the mass becomes homogeneous, uniform in colour and consistency.

III. RESULTS AND DISCUSSION

3.1 COMPRESSIVE STRENGTH

Compressive strength is the capacity of a materialor structure to withstand axially directed pushing forces. When the limit of compressive strength is reached, materials are crushed. Concrete can be made to have high compressive strength. The compressive strength of a material is that value of uniaxial compressive stress reached when the material fails completely. The compressive strength is usually obtained experimentally by means of a compressive test.

By its basic definition the uniaxial stress is given by:

$$\sigma = \frac{F}{A}$$

Where F = Load applied [N], A = Area [mm^2]

Table 1:Compressive Strength of Cubes of ‘A’ Series

S.NO.	**SERIES**	**CONTROL MIX**	**COMPRESSIVE STRENGTH(Mpa)**
1	A_1	[C+ 5% FLY ASH + 5 % GGBS] +F.A +C.A+1 % S.P	56.33
2	A_2	[C+ 5% FLY ASH + 10 % GGBS] +F.A +C.A+1 % S.P	59.33
3	A_3	[C+ 5% FLY ASH + 15 % GGBS] +F.A +C.A+1 % S.P	53.33

Table 2: Compressive Strength of Cubes of ‘B’ Series

SNO	SERIES	CONTROL MIX	COMPRESSIVE STRENGTH (mpa)
1	B_1	[C+10% FLY ASH + 5 % GGBS] +F.A +C.A+1 % S.P	58
2	B_2	[C+10% FLY ASH + 10 % GGBS] +F.A +C.A+1% S.P	55
3	B_3	[C+10% FLY ASH + 15 % GGBS] +F.A +C.A+1% S.P	54.33

Table 3: Compressive Strength of Cubes of 'C' Series

SNO	SERIES	CONTROL MIX	COMPRESSIVE STRENGTH (mpa)
1	C_1	[C+15% FLY ASH + 5 % GGBS] +F.A +C.A+1 % S.P	53.67
2	C_2	[C+15% FLY ASH + 10 % GGBS] +F.A +C.A+1% S.P	45.33
3	C_3	[C+15% FLY ASH + 15 % GGBS] +F.A +C.A+1% S.P	41.67

From the test results it is observed that strength increases while increasing the GGBS % up to an optimum limit of GGBS %, after that the strength values are decreasing.

3.2 TENSILE STRENGTH

Tensile strength is the maximum stress that a material can withstand while being stretched or pulled before necking, which is when the specimen's cross-section starts to significantly contract. The UTS is usually found by performing a tensile test and recording the stress versus strain; the highest point of the stress-strain curve is the UTS. It is an intensive property; therefore its value does not depend on the size of the test specimen. However, it is dependent on other factors, such as the preparation of the specimen, the presence or otherwise of surface defects, and the temperature of the test environment and material. Tensile strength is defined as a stress, which is measured as force per unit area.

$$\text{Split tensile strength} = \frac{2P}{\pi LD}$$

Where P is the compressive load on the cylinder

L is the length of cylinder, D is the diameter

Table 4:Tensile Strength of "A" Series Cylinders

SNO	SERIES	CONTROL MIX	TENSILE STRENGTH (mpa)

1	A_1	[C+ 5% FLY ASH + 5 % GGBS] +F.A +C.A+1 % S.P	3.61
2	A_2	[C+ 5% FLY ASH + 10 % GGBS] +F.A +C.A+1 % S.P	3.68
3	A_3	[C+ 5% FLY ASH + 15 % GGBS] +F.A +C.A+1 % S.P	3.61

Table 5: Tensile Strength of "B" Series Cylinders

SNO	**SERIES**	**CONTROL MIX**	**TENSILE STRENGTH (mpa)**
1	B_1	[C+10% FLY ASH + 5 % GGBS] +F.A +C.A+1 % S.P	3.26
2	B_2	[C+10% FLY ASH +10 % GGBS] +F.A +C.A+1 % S.P	3.54
3	B_3	[C+10% FLY ASH +15 % GGBS] +F.A +C.A+1 % S.P	3.12

Table 6: Tensile Strength of "C" Series Cylinders

SNO	**SERIES**	**CONTROL MIX**	**TENSILE STRENGTH (mpa)**
1	C_1	[C+15% FLY ASH + 5 % GGBS] +F.A +C.A+1 % S.P	2.41
2	C_2	[C+15% FLY ASH +10 % GGBS] +F.A +C.A+1 % S.P	2.83
3	C_3	[C+15% FLY ASH +15 % GGBS] +F.A +C.A+1 % S.P	2.69

From the test results it is observed that tensile strength increases while increasing the GGBS % up to a optimum limit of GGBS %, after that the strength values are decreasing.

3.3 FLEXURAL STRENGTH

Flexural strength is defined as a material's ability to resist deformation under load. The transverse bending test is most frequently employed, in which a rod specimen having either a circular or rectangular cross-section is bent until fracture using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of rupture. When an object formed of a single material, like a wooden beam or a steel rod, is bent. It experiences a range of stresses across its depth. At the edge of the object on the inside of the bend the stress will be at its maximum compressive stress value. At the outside of the bend the stress will be at its maximum tensile value. These inner and outer edges of the beam or rod are known as the 'extreme fibbers. Most materials fail under tensile stress before they fail under compressive stress, so the maximum tensile stress value that can be sustained before the beam or rod fails is its flexural strength.The flexural strength of the specimen is expressed as the modulus of rupture

$$f_b = \frac{PL}{bd^2}$$

Where, P = maximum load in KN applied to the specimen.

L = length in mm of the span on which the specimen was support.

d = measured depth in mm of the specimen at the point of failure.

b = measured width in mm of the specimen.

Table 7: Flexural Strength of “A” Series Prisms

SNO	SERIES	CONTROL MIX	FLEXURAL STRENGTH (mpa)
1	A_1	[C+ 5% FLY ASH + 5 % GGBS] +F.A +C.A+1 % S.P	12.6
2	A_2	[C+ 5% FLY ASH + 10 % GGBS] +F.A +C.A+1 % S.P	13.78
3	A_3	[C+ 5% FLY ASH + 15 % GGBS] +F.A +C.A+1 % S.P	14.49

Table 8: Flexural Strength of “B” Series Prisms

SNO	SERIES	CONTROL MIX	FLEXURAL STRENGTH (mpa)
1	B_1	[C+10% FLY ASH + 5 % GGBS] +F.A +C.A+1 % S.P	12.70
2	B_2	[C+10% FLY ASH +10 % GGBS] +F.A +C.A+1 % S.P	9.84
3	B_3	[C+15% FLY ASH + 15% GGBS] +F.A +C.A+1 % S.P	10.52

Table 9: Flexural Strength of “C” Series Prisms

SNO	SERIES	CONTROL MIX	FLEXURAL STRENGTH (mpa)
1	C_1	[C+15% FLY ASH + 5 % GGBS] +F.A +C.A+1 % S.P	11.34
2	C_2	[C+15% FLY ASH +10 % GGBS] +F.A +C.A+1 % S.P	15.08
3	C_3	[C+15% FLY ASH +15 % GGBS] +F.A +C.A+1 % S.P	15.18

From the test results it is observed that Flexural strength decreases while increasing the GGBS % up to a optimum limit of GGBS %, after that the strength values are increasing.

IV. CONCLUSIONS

In 'A' series, i.e. themixes with Fly Ash and GGBS in different proportions, the compressive strength, tensile strength, flexural strengths values are:

In the first set of casting, i.e., Fly ash and GGBS as an admixture, with Fly ash is constant at 5% & GGBS has a different mix proportion.

- Then the compressive strength values are increased by increasing the GGBS % up to 10% respectively. The compressive strength value at 10% GGBS is 5.3% more than 5% of GGBS. While in increase of GGBS up to 15% the value decreased by 11.25%.
- Then the Tensile strength values are increased by increasing the GGBS % up to 10%. The tensile strength value at 10% of GGBS is 1.92% more than the tensile strength value at 0% GGBS and The tensile strength value at 15% of GGBS is 1.92% less than the tensile strength value at 10% GGBS
- Then the Flexural strength values are increased by increasing the GGBS % .The Flexural strength value at 10% of GGBS is 9.3% more than the tensile strength value at 5% GGBS and The tensile strength value at 15% of GGBS is 5.2% more than the tensile strength value at 10% GGBS

In 'B' series, i.e. the mixes with fly ash and GGBS in different proportions, the compressive strength, tensile strength, flexural strengths values are:

In the second set of casting, i.e., Fly ash and GGBS as an admixture, with Fly ash is constant at 10% & GGBS has a different mix proportion.

- Then the compressive strength values are decreasing by increasing the GGBS%. The compressive strength value at 10% of GGBS is 5.5% less than at 5% of GGBS. While in increase of GGBS up to 15% the values decreased by 1.2%.
- Then the Tensile strength values are increased by increasing the GGBS % up to 10%. The Tensile strength value at 10% of GGBS is 8.6% more than the tensile strength value at 05%

of GGBS and the tensile strength value at 15% GGBS is 13.5% less than the tensile strength value at 10% GGBS.

- Then the Flexural strength values are decreased by increasing the GGBS % up to 10%. The flexural strength value at 10% of GGBS is 29.1% less than the tensile strength value at 5% of GGBS and the flexural strength value at 15% GGBS is 6.9% more than the tensile strength value at 10% GGBS.

In ‘C’ series, i.e. the mixes with fly ash and GGBS in different proportions, the compressive strength, tensile strength, flexural strengths values are:

In the third set of casting, i.e., Fly ash and GGBS as an admixture, with Fly ash is constant at 15% & GGBS has a different mix proportion.

- Then the compressive strength values are decreasing by increasing the GGBS%. The compressive strength value at 10% of GGBS is 18.39% less than at 5% of GGBS. While in increase of GGBS up to 15% the values decreased by 8.7%.
- Then the tensile strength values are increasing by increasing the GGBS % up to 10%. The tensile strength value at 10% of GGBS is 17.4% more than at 05% of GGBS. While in increase of GGBS up to 15% the values decreased by 5.2%.
- Then the Flexural strength values are increased by increasing the GGBS% .The Flexural strength value at 10% of GGBS is 33.0% more than the tensile strength value at 05% GGBS and The flexural strength value at 15% of GGBS is 0.7% more than the tensile strength value at 10% GGBS

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