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# Optimization of Mix Proportion for High Strength Concrete Using GGBS

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**Abstract -** Concrete is one of the foremost wide used construction materials, and it's sometimes associated with cement because of the main element for creating concrete. The use of (HSC) construction, particularly for multi-story buildings, has become quite common in industrialized and developing countries. The mandatory ingredient of HSC like a ground granulated blast furnace (GGBS). Super plasticizer is getting used in these concretes to realize the specified workability. This investigation principally centered on the strength properties of GGBS based HSC. During this study the mix was designed with a powder content range of 230 Kg/m$^3$ to 700Kg/m$^3$. GGBS is used at different replacement levels from 30% to 60% production of HSC. During this study, fresh properties of concrete and the slump flow values are studied to find the workability of fresh concrete, the compressive strength of HSC was determined once 3, 7, and 28 days of curing. Ascertained that the GGBS - based mostly concrete earned the specified high strength based mostly HSC earn additional strength properties when put next to those of GGBS - based mostly HSC.

***Key Words***: High strength concrete, GGBS, Slump flow test, compressive strength test.

## I. INTRODUCTION

Concrete is the most commonly used and preferred material for construction purposes throughout the world the concrete is durable and easy to make for the construction of high-rise buildings at the construction site. It is easy to transport and it can place where the concrete need, The high-strength concrete can be easily molded into any desired shape and size by using different molds and casting specimens like wood molds and steel molds the concrete is cannot expand in any conditions remains constant. The main ingredient of the concrete is easily available in most places which makes concrete even more popular according to the IS 456:2000 and IS 10262-2019. The plain to the reinforced concrete and code practice and mix design code practice for ordinary concrete and, Standard concrete and High strength concrete. (HSC)

### Historical background

High-strength concrete is much of the time considered a material, its improvement has been slow over numerous years. In the USA, during the 1950s concrete with a compressive strength of 34 MPa was viewed as high strength, during the 1960s, concrete with 41 to 52mpa compressive strength was utilized economically. inside the mid-1970', 62mpa cement was being made inside the world situation less, inside the most recent fifteen years, cement of high strength entered the area of development, the specific requirement of elevated structures and long-range spans. in accordance with code IS 456-2000 compressive strength over 110 MPa has been pondered for applications in cast setup structures and prestressed substantial individuals.

### Research significance

As expressed in the introduction, one in all objectives of this analysis was to supply knowledge from a scientific investigation and therefore on contribute to the event of High-strength specifications for HSC. though the latter wasn't a part of this analysis, it had been thought about to be essential to living each physical properties and sturdiness characteristics of HSC containing each binary and ternary blends of Portland cement and supplementary building material materials. the factors for assessing the standard of hardened HSC area unit captivated with their supposed functions.

### Development of High Strength Concrete

The development of high-strength concrete is predicated on the water-cement (water-binder) quantitative relation. For the high-strength concrete, the w/c quantitative relation ought to be unbroken low. The utilization of low water-cement quantitative relation and different building materials create the utilization of polycarboxylate ether-based on Super plasticizers ought to be wont to win most water reduction, though plasticizers are also adequate for lower strength. Increasing the cement content might not continuously turn out higher strength.

**Advantages of high strength concrete**

- These include a decrease in member size.
- Decrease in the self-weight and superimposed dead load with the accompanying saving due to smaller foundations.
- decrease in form work area and cost.
- Longer spans and fewer beams for the same magnitude of loading.
- Decrease axial shortening of compression members

## APPLICATIONS OF HIGH STRENGTH CONCRETE

- High rise Buildings and structures
- Prestressed concrete members
- Highway payments
- Hydropower structures

## OBJECTIVES AND SCOPE OF THIS PROJECT

This investigation is mainly focused on the development of high-strength concrete (HSC) using mix design, especially for HSC by varying the replacement levels of GGBS is varied from 30% to 50%. Based on the background of this project, the research the following stages.

- To study the fresh properties of slump flow test by workability of concrete different GGBS replacement levels
- To study the Compressive strength of GGBS -based HSC after 3, 7, and 28 days of curing.

## II. Literature review

(1) **Dr. Arun Kumar** (2009) Studied The GGBS As limited displacement Of OPC In Cement Concrete And Experimental Study the main aim of the study is to obtain the suitability of GGBS as a displacement of OPC in concrete. It may be observed from the plots that the properties of can be maintained with GGBS as a limited displacement of cement up to 20%. The increase in % of GGBS results in a decrease in the strength of concrete. The reduction in the cost of concrete at the current market rate is 14%, in the case of GGBS as displacement of OPC by 20%.

(2) **Reshma Rughooputh And Jaylina Rana** (2010) The limited displacement of OPC with GGBS improves the workability but causes a decrease inside the plastic density of the concrete. The compressive and tensile ripping strengths, flexure, and modulus of property increase with increasing GGBS content. The drying shrinkage shows a little increment with GGBS. GGBS fails the initial surface absorption check confirming that the surfaces of their concrete mixes were abundantly rubberized. supported the results, the optimum mix is the one with 5 hundredths OPC 0% GGBS.

(3) **Sonali K. Gadpalliwar, R. S. Deotale, Abhijeet R. Narde** (2012) it is found that by increasing the GGBS workability can increase but strength decreases. the utmost 28-day split permanence was obtained with the unit of time GGBS was replaced with cement. sensible compressive strength is obtained once 2.5% GGBS + 5% is replaced with cement and natural sand is replaced by time unit quarry sand.

(4) **Sonali K. Gadpalliwar, R. S. Deotale, Abhijeet R. Narde** (2012)The Partial displacement Of Cement By GGBS & And Natural Sand By Quarry Sand In Concrete it is found that by increasing the GGBS workability can increase but strength decreases. the utmost 28-day split permanence was obtained with a unit of time GGBS replaced with cement. sensible compressive strength is obtained once 2.5% GGBS + 5% is replaced with cement and natural sand is replaced by time unit quarry sand.

## III. EXPERIMENTAL PROGRAM

In this project, the first stage includes raw materials and their properties no of trails and mixes In this present investigation concrete mix design M70 to M90 was designed IS 10262-2019 In this study, The displacement of levels of GGBS varied from 30% to 50%. Low water to cementitious ratio was maintained for all High strength concrete mixes. Super plasticizer (SP) dosage at 0.8% for all High strength concrete mixes. The coarse aggregate and fine aggregate proportions were 63% and 37% respectively this code provides generally a method for selecting mixture proportion for high strength concrete and optimizing the mix proportion on the basis of trial batches, The method is limited to high strength concrete production using conventional materials.

### Cement

we used Birla A1 OPC grade cement. The Ordinary Portland cement of 53 grade conforming to IS:12269-2013. Tests we are conducted on cement are specific gravity, setting test, compressive strength test $N/mm^2$

### Ground Granulated Blast Furnace Slag

In the present investigation, GGBS was brought from Ultra Tech RMC plant Tirupati. Ground Granulated Blast Furnace slag is one of the mineral admixtures and it is obtained from the quenching of iron slag a by-product of iron and steel. Conforming to the IS 12089-:1981 and GGBS specific gravity is 2.9. Concrete made with GGBS cement sets more slowly than concrete made with ordinary portland cement, depending on the amount of GGBS added to the cementitious material but also continues to gain strength

over a longer period in production conditions. This outcomes in a lower intensity of hydration and a lower temperature climb and make keeping away from cold joints more straight forward. but may also affect the construction schedule where a quick setting is required. ground granulated blast furnace slag is one of the mineral admixtures and it is obtained from the quenching of iron slag a by-product of iron and steel made from a shoot heater in water or steam, to deliver a shiny, granular item that is dried and ground into a fine powder properties is shown in Table 1

**Fig: 1** GGBS

**Table:1** Properties of GGBS

| PROPERTIES | GGBS |
|---|---|
| Colour | Off- white |
| Specific gravity | 2.9 |
| Bulk density | 1200Kg/m$^3$ |
| Fineness | 350 m$^2$/kg |

## coarse aggregate :

In this project, I use natural aggregates of crushed granite stone of size 10 mm was used as coarse aggregate. The bulk specific gravity in oven dry conditions and water absorption of the coarse aggregate 10mm as per IS 2386 (Part III) were 2.6 and 0.3% respectively. The gradation of the coarse aggregate was determined by sieve analysis as per IS 383 (2016).

## fine aggregate :

In this project, I used natural river sand was used as fine sand. the bulk gravity in oven dry condition and water absorption of the sand as per 2386 (part 3) zone II were 2.6 and 1 % respectively. radiation of the sand was determined by sieve Analysis as per IS383 -2006.

## Super Plasticizer

In this study, Conplast 430 used a polycarboxylate ether-based superplasticizer (SP). It is brought from Astra chemicals, Chennai. Superplasticizers are standard compound admixtures for concrete utilized in the decrease of water to solidify quantitative connection while not moving functionality and to stay away from molecule accumulation inside the substantial combination. These are called high change water reducers(HRWR) and their specific gravity is 1.08.

## Water

In this project, I use casting and curing of specimens were done using portable water. it should be good quality and free from chemical impurities harm full greasy and oil substances.

## Mix Design

In this present investigation concrete mix design M70 to M90 was designed IS 10262-2019 In this study, The replacement of levels of GGBS varied from 30% to 50%. Low water to cementitious ratio was maintained for all High strength concrete mixes. Super plasticizer (SP) dosage at 0.8% for all High strength concrete mixes. The coarse aggregate and fine aggregate proportions were 63% and 37% respectively this code provides generally a method for selecting mixture proportion for high strength concrete and optimizing the mix proportion on the basis of trial batches, The method is limited to high strength concrete production using conventional materials and production techniques. Mix proportions details are given below in table 2

**Table :2** GGBS blended HSC mix proportions

| Mix | Cementitious Kg/m$^3$ | Cement Kg/m$^3$ | GGBS Kg/m$^3$ |
|---|---|---|---|
| C400GGBS230 | 630 | 400 | 230 |
| C770GGBS330 | 1100 | 770 | 330 |
| C770GGBS440 | 1210 | 770 | 440 |
| C770GGBS630 | 1400 | 770 | 630 |
| C770GGBS770 | 1540 | 770 | 770 |
| C900GGBS90 | 1290 | 900 | 390 |
| C900GGBS510 | 1490 | 900 | 510 |

**Table: 3** GGBS blended HSC mix proportions

| Water Litre/m$^3$ | W/cm | 10mm Kg/m$^3$ | Sand Kg/m$^3$ | Sp % |
|---|---|---|---|---|
| 190.4 | 0.33 | 978.54 | 574.69 | 0.8 |
| 190.4 | 0.19 | 723.89 | 425.20 | 0.8 |
| 190.4 | 0.17 | 660.11 | 387.7 | 0.8 |
| 190.4 | 0.15 | 550.37 | 323.23 | 0.8 |
| 190.4 | 0.14 | 468.47 | 275.13 | 0.8 |
| 190.4 | 0.16 | 620.8 | 364.68 | 0.8 |
| 1904 | 0.15 | 550.36 | 323.23 | 0.8 |

**Table:4** Parameters of GGBS mix proportions

| Mix | Cementitious | Cement Kg/m³ | GGBS Kg/m³ |
|---|---|---|---|
| C400GGBS230 | 630 | 400 | 230 |
| C400GGBS230 | 1100 | 770 | 330 |
| C400GGBS230 | 1210 | 770 | 440 |
| C400GGBS230 | 1400 | 770 | 630 |
| C400GGBS230 | 1540 | 770 | 770 |
| C400GGBS230 | 1290 | 900 | 390 |
| C400GGBS230 | 1410 | 900 | 510 |

## Mixing procedure

In this project we use A pan mixer machine (40 kg capacity) is used to mix HSC. we add cement, Ground Granulated Blast furnace Slag, are placed in the mixer, and mixing is done for 3 minutes. (120 rpm) for one minute and it is added to the mix. Then GGBS is added and mixed for 3 minutes. water along with half of SP is added and mixed for 2 minutes. When proper blending of ingredients is observed, remaining SP and water are added and mixed for 3 minutes. When consistency is observed, are added slowly then mixing is continued for 2 minutes.

**Table:5** GGBS blended mix proportions

| W/CM | GGBS/Cement | %GGBS |
|---|---|---|
| 0.35 | 0.6 | 35 |
| 0.19 | 0.4 | 30 |
| 0.17 | 0.6 | 35 |
| 0.15 | 0.8 | 45 |
| 0.14 | 1 | 50 |
| 0.16 | 0.4 | 30 |
| 0.15 | 0.6 | 35 |

## Specimen preparation and curing

For each mix 6 cubes are cast. Size of cube is 100mmx 100mmx100mm. curing of cubes is done in normal water for curing.

### Testing

Cubes were tested for compressive strength and 3 days,7 days, and 28 days respectively. They are tested under Compression Testing Machine (CTM) for compressive strength

## IV. Results and Discussions

### Slump flow test

In this test, I can calculate the workability of fresh concrete the concrete should spread on the surface in the circular area when we lift the cone vertically upwards. This test was conducted for all mixes with various mix proportions by using GGBS in the replacement of 30% to 60%. It is observed that the increase of GGBS replacement decreased the slump values of high strength concrete mixes we can calculate the slump Slump flow test of concrete is the test of measuring the workability of concrete which is extensively used in construction site-work all over the world. The slump cone has filled the concrete and the mold is then removed from the concrete immediately by raising it slowly and carefully in a vertical direction. The slump flow spread is measured by determining the diameter of the concrete spread in the surface

**Table:6** Slump flow values for ggbs mix for HSC

| Mix | Cementitious Kg/m³ | %GGBS | SLUMP FLOW MM |
|---|---|---|---|
| C400GGBS230 | 630 | 35 | 551 |
| C770GGBS330 | 1100 | 30 | 590 |
| C770GGBS440 | 1210 | 35 | 628 |
| C770GGBS630 | 1400 | 45 | 619 |
| C770GGBS770 | 1540 | 50 | 572 |
| C900GGBS390 | 1290 | 30 | 662 |
| C900GGBS510 | 1410 | 35 | 648 |

It is observed that the increase in GGBS replacement decreased the slump flow of HSC mixes

## Compressive strength test

**Table:7** Compressive strength for GGBS blend

| Mix | Compressive strength (MPa) | | | Grade |
|---|---|---|---|---|
| | 3 days | 7 days | 28 days | |
| C400GGBS230 | 64 | 73 | 78 | M70 |
| C770GGBS330 | 73 | 81 | 85 | M80 |
| C770GGBS440 | 73 | 83 | 89 | M80 |
| C770GGBS630 | 72 | 82 | 84 | M70 |
| C770GGBS770 | 65 | 76 | 79 | M70 |
| C900GGBS390 | 74 | 89 | 92 | M80 |
| C900GGBS510 | 66 | 77 | 82 | M70 |

Compressive strength of M70 to M80 was determined during the 3 days, 7 days, and 28 days of curing, and their results From the above results, it is observed that HSC mixes achieved M70 andM80 grade of concrete after 28 days of curing. Among the mixes C770GGBS330,C770GGBS440,C770GGBS630 and C770GGBS770,the two mixes C770GGBS330 and C770GGBS440 attained M80 grade strength. The other two mixes C770GGBS630 and C770GGBS770 attained M70 grade strength. The mixes C400GGBS230, C770GGBS630, C770GGBS770 and C900GGBS510 attained M70 grade strength. The mixes C770GGBS330, C770GGBS440 and C900GGBS390 attained M80 grade strength.

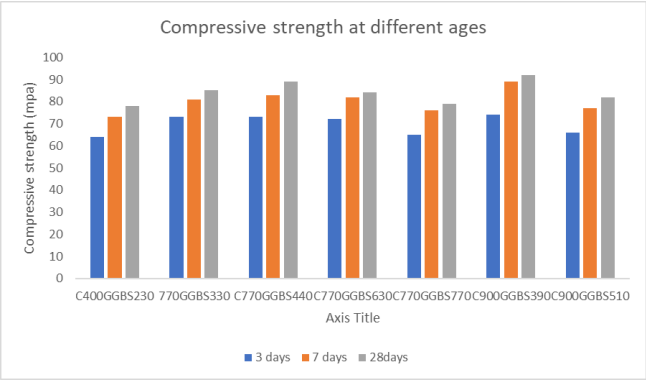


**FIG 2:** Compressive strength at different ages

**Table 8 :**compressive strength of GGBS test results

| % GGBS | Compressive strength (MPa) | | | Grade |
|---|---|---|---|---|
| | 3 days | 7 days | 28 days | |
| 30 | 73 | 81 | 85 | M80 |
| 35 | 73 | 83 | 89 | M80 |
| 45 | 72 | 82 | 84 | M70 |
| 50 | 65 | 76 | 79 | M70 |

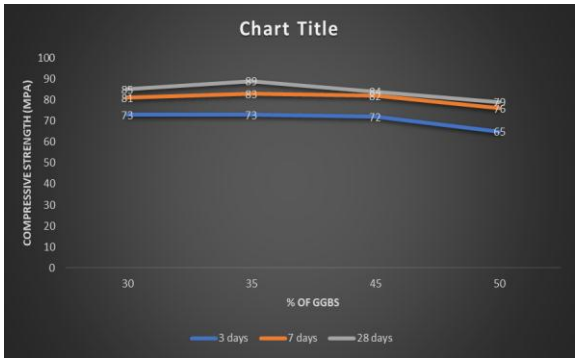


**Fig:3** variation of compressive strength versus % of GGBS in HSC

## V. Conclusions

1. It is observed that the increase of GGBS replacement decreased the slump flow values of High strength concrete mixes.
2. The mix C900GGBS390 the replacement of GGBS in 30% increased the maximum slump value to be attained.
3. Compressive strength of mix C400GGBS230 with 35% GGBS achieved the M70 grade concrete 28 days of curing.
4. Compressive strength of mix C770GGBS630 with 45% GGBS achieved the M70 grade concrete 28 days of curing.
5. Compressive strength of mix C770GGBS330 with 30% GGBS achieved the M80 grade concrete 28 days of curing.
6. Compressive strength of mix C900GGBS390 with 30% GGBS achieved the M80 grade concrete 28 days of curing.
7. Compressive strength of mix C770GGBS440 with 35% GGBS achieved the M80 grade concrete 28 days of curing.

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