RESEARCH ARTICLE OPEN ACCESS

# Comparison of Strength for Concrete with GGBS and Cement Using Accelerated Curing Method

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**ABSTRACT**
Ground granulated blast-furnace slag ( GGBS) is the **granular material** formed iron ore is molted. blast furnace slag is by-product of steel manufacture which is sometimes used as a substitute for Portland cement. In steel industry when iron ore is molted, then in the molted state all the impurities come at its surface which are removed called slag. It consists mainly of the silicates and alumino silicates of calcium, which are formed in the blast furnace in molten form simultaneously with the metallic iron. Blast furnace slag is blended with Portland cement clinker to form portland blast furnace slag cement.

GGBS is used to make durable concrete structures in combination with ordinary Portland cement and/or other pozzolanic materials. GGBFS has been widely used in Europe, and increasingly in the United States and in Asia (particularly in Japan and Singapore) for its superiority in concrete durability, extending the lifespan of buildings from fifty years to a hundred years.

This project presents the feasibility of the usage of GGBS as hundred percent substitutes for Ordinary portland cement in concrete. Design mix for M20 and M30 has been calculated using IS 10262-2009 for both accelrated curing in warm water and accelrated curing in boiling water method. Tests were conducted on cubes to study the strength of concrete by using GGBS and Ordinary portland cement

***Keywords*:** GGBS, Ordinary Portland Cement, Replacement, Mix Design and Curing

## I. INTRODUCTION

The reuse of industrial by products is gaining popularity since last few decades due to its long-term performance characteristics. Concrete is known for its compressive strength which is an important property in the design and the construction of the concrete structures. Although, concrete is very strong in compression, but, due to the development of various types of admixtures, it is necessary to investigate the effect of mineral admixtures on the compressive strength concrete. Concrete is a composite made up of filler and a binder. The binder is a product of reaction between hydraulic cement and water, glues the filler together to form a synthetic conglomerate. Aggregates are the solid particles that are bonded together by the cement paste to create concrete. Aggregates are the fundamental components of concrete. The coarse aggregate, being the principal control material for maximum strength, sand as fine aggregate fills most of the voids , providing lateral restraints (inter - particle locking) to the coarse particles.

Aggregates occupy around 70% to 80% of the volume of concrete. Generally, aggregates are given less importance by assuming them to be only as economic inert filters, but they influence the strength, dimensional stability, wear resistance and durability of concrete.

Because of tremendous growth in population, urbanization and advanced technologies of construction, there is a vast consumption of energy and resources in the production of concrete. In the earlier times, the main emphasis was on labour productivity. This was because the resources were abundant and environment was healthy, where as now population is abundant and resources are getting depleted at a faster rate. At the same time, several tones of waste is produced per day from various industries. The use of by- products for production of concrete is the only real potential for the utilization of larger quantities of waste material. However, there is growing interest in substituting alternative materials for concrete

## II. OBJECTIVES OF STUDY

- To find the compressive strength of M20 and M30 concretes by conventional 28 days curing period method .

- To find the compressive strength of M20 and M30 concretes with 10%, 20% and 30% replacement of cement with GGBS by conventional 28 days curing period as per IS-516-1978.
- To find the compressive strength of M20 and M30 mix concretes by warm water method of accelerated curing method i.e. at $55^0 \pm 2^oC$ temperature as per IS-9013-1978.
- To find the compressive strength of M20 and M30 concretes by boiling water method of accelerated curing method i.e. at $100^0 \pm 3^oC$ temperature as per IS-9013-1978.
- To find the compressive strength of M20 and M30 concretes with 10%, 20% and 30% replacement of cement with GGBS ash by warm water method of accelerated curing method i.e. at $55^0 \pm 2^oC$ temperature as per IS-9013-1978.
- To find the compressive strength of M20 and M30 concretes with 10%, 20% and 30% replacement of cement with GGBS boiling water method of accelerated curing method i.e. at $100^0 \pm 3^oC$ temperature as per IS-9013-1978.

## III. LITERATURE REVIEW

**Previous Studies:**

**P. L. Domone; M. N. Soutsos (1989)** studied The effects of incorporating pulverized fuel ash (PFA) and ground granulated blast furnace slag (GGBS) on the workability (slump), adiabatic temperature rise during hydration and long-term (up to 570 days) strength of high-strength concretes have been measured. Binary (PFA/GGBS and Portland cement) and ternary (PFA/ggbs plus microsilica and Portland cement) blends at water–binder ratios from 0·38 to 0·20 have been tested. The results show broadly similar effects to those in lower strength concrete, although of differing magnitude in some cases. Some potential advantages of ternary blends for optimization of properties have been demonstrated.

**Present Study:**

In the present investigation we design mix for M20 and M30 has been calculated using IS 10262-2009 for both accelerated curing in warm water and accelerated curing in boiling water methods. Tests were conducted on cubes to study the strength of concrete by using GGBS and the results were compared with the Natural Concrete. During the present study, 0%, 10%, 20% and 30% of traditional cement was replaced with GGBS. Compressive strengths were found after 3,7 and 28days of curing.

It is observed from the above data that the studies conducted by the researchers on the accelerated curing method are limited. That is why the focus is aimed on Indian standard method of making, curing and determining compressive strength of accelerated-cured concrete cube test specimens with variable percentages of ggbs replacement based on IS: 9013-1978.

## IV. CURING METHODS:

a) Water curing (b) Membrane curing
(c ) Application of heat (d) Miscellaneous

**4.1 Miscellaneous Methods:**

**4.1.1 Accelerated Curing by Warm Water Method:** After the specimens have been made, they shall be left to stand undisturbed in their moulds in a place free from vibration at a temperature of $27 \pm 2^0$ C for at least one hour, prior to immersion in the curing tank. The time between the addition of water to the ingredients and immersion of the test specimens in the curing tank shall be at least $1\frac{1}{2}$ hours but shall not exceed $3\frac{1}{2}$ hours. The specimens in their moulds shall be gently lowered into the curing tank and shall remain totally immersed at $55 \pm 2^0$ C for a period of not less than 19 hours 50 minutes. The specimens shall then be removed from the moulds and immersed in the cooling tank at $27 \pm 2^0$ C before the completion of 20 hours 10 minutes from the start of immersion in the curing tank. They shall remain in the cooling tank for a period of not less than one hour.

**4.1.2 Accelerated Curing by Boiling Water Method:** After the specimens have been made, they shall be stored in a place free from vibration, in a moist air of at least 90 percent relative humidity and at a temperature of $27 \pm 2^0$ C for 23 hours $\pm$ 15 minutes from the time of addition of water to the ingredients.

The specimens shall then be gently lowered into the curing tank and shall remain totally immersed for a period of $3\frac{1}{2}$ hours ± 5 minutes. The temperature of water in the curing tank shall be at boiling ($100^0$ C) at sea level. The temperature of water shall not drop more than $3^0$ C after the specimens are placed and shall return to boiling within 15 minutes. After curing for $3\frac{1}{2}$ hours ± 5 minutes in the curing tank, the specimen shall be removed from the boiling water, removed from the moulds and cooled by immersing in cooling tank at $27 \pm 2^0$ C for 2 hours. To find comparative statement for compressive strength of different mix of concrete M20 and M30 with Partial replacement of cement for different types of curing methods .

## V. EXPERIMENTAL INVESTIGATIONS

### 5.1 Compressive Strength Test:

According to IS: 516-1959**,** the test set up for conducting cube compressive strength test is depicted in Plate No. Compression test on the cubes is conducted on the 300T compression testing machine. The cube was placed in the compression testing machine and the load on the cube is applied at a constant rate up to the failure of the specimen and the ultimate load is noted. The cube compressive strength of the concrete mix is then computed.. This test has been carried out on cube specimens at 3,7,28 and 56 days age. The values are presented in tables 6.10 and 6.2 for M20 and M30 concrete respectively.

Compressive strength = $\frac{P}{A}$

Where, p = maximum load in kg applied to the specimen

A = cross sectional area of the cube on which load is applied (150 X 150 mm)

### 5.1.1 Compressive Strength Test Using Boiling Water Accelerated Curing Method:

1. After the test specimens (whose 28 days strength to be determined) have been casted, store it in moist air of at least 90 percent humidity for 23 hours ±15 min.
2. Cover the specimens with flat steel cover plate to avoid distortion during the use.
3. Carefully and gently lower the specimens into the curing tank and shall remain totally immersed for a period of 3½ Hours±15 min.
4. The temperature of water in the curing tank shall be at boiling (100 $^{o}$C ± 3 $^{o}$C ) when the specimens are placed.
5. After curing for 3 ½ hours in boil water, the specimen shall be carefully removed from the boiling water and cooled by immersing in cooling tank at 27±2$^{o}$C for 2 hrs.
6. After cooling remove the specimens from the mould and tested for its accelerated compressive strength in N/mm$^2$.

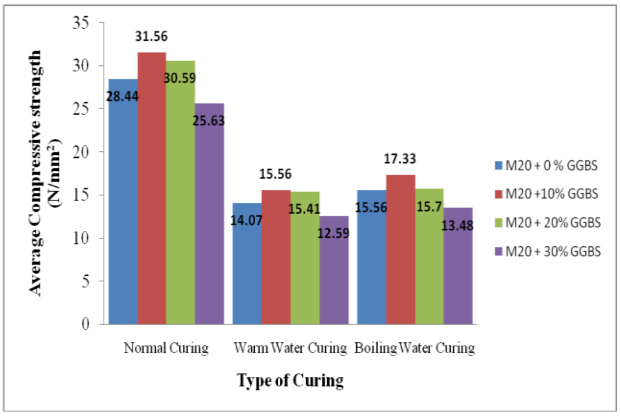
### 5.1.2 Compressive Strength Test Using Hot Water Accelerated Curing Method:

1. The specimens in their moulds shall be gently lowered into the curing tank and shall remain totally immersed at 55°C ± 2°C for a period of not less than 19 hours 50 minutes. The specimens shall then be removed from the water, marked for identification, removed from the mould and immersed in the cooling tank at 27 °C ± 2°C before the completion of 20 hours 10 minutes from the start of immersion in the curing tank. They shall remain in the cooling tank for a period of not less than one hour.
2. Cover the specimens with flat steel cover plate to avoid distortion during the use.
3. The temperature of water in the curing tank shall be at boiling (55 $^{o}$C ± 2 $^{o}$C) when the specimens are placed.
4. After cooling remove the specimens from the mould and tested for its accelerated compressive strength in N/mm$^2$.

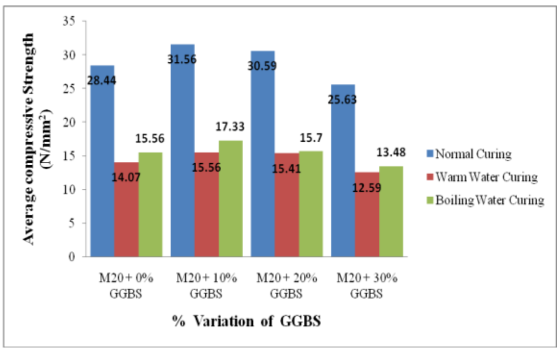
## VI. FIGURES AND TABLES:

### 6.1 Average Compressive Strength of M20 Mix Cubes by Normal Curing, Hot Water Curing, Boiling Water Curing

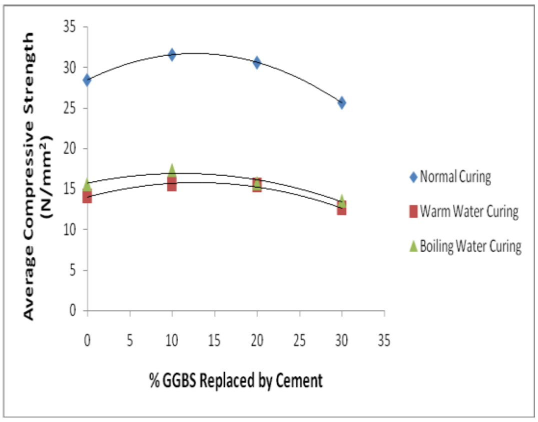
| Method of Curing | Average Compressive Strength of Cubes ( N/ mm$^2$) | | | |
|---|---|---|---|---|
| | M20 + 0% GGBS | M20 + 10% GGBS | M20 + 20% GGBS | M20 + 30% GGBS |
| Normal Curing | 28.44 | 31.56 | 30.59 | 25.63 |
| Warm Water Curing | 14.07 | 15.56 | 15.41 | 12.59 |
| Boiling Water Curing | 15.56 | 17.33 | 15.70 | 13.48 |




Average Compressive Strength vs Types of Curing for M20 Mix

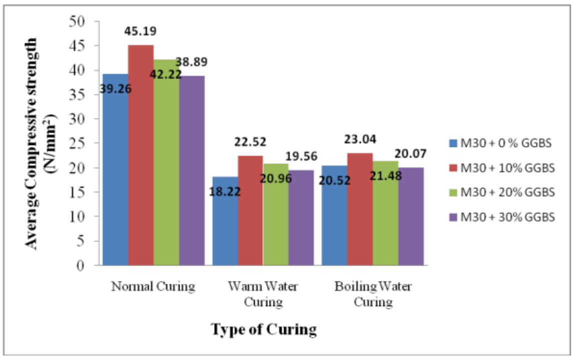



Average Compressive Strength vs % Variation of GGBS for M20 Mix

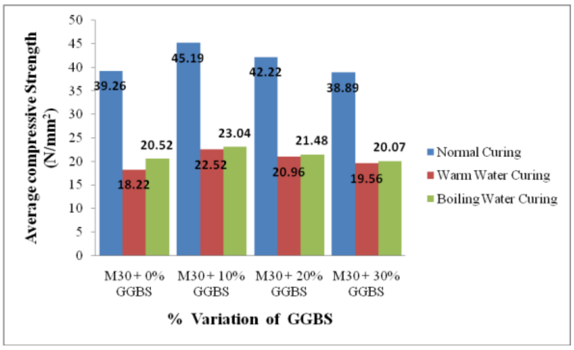



Average Compressive Strength of M20 Mix vs % Replacement of GGBS

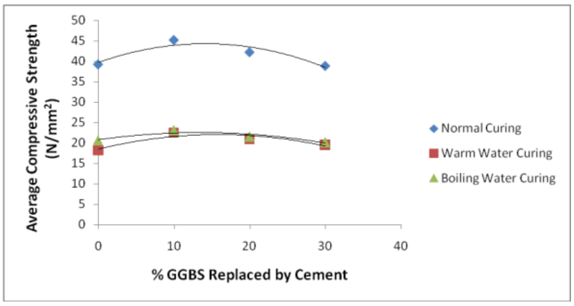
**6.2.Average Compressive Strength of M30 Mix Cubes by Normal Curing, Hot Water Curing, Boiling Water Curing**




Average Compressive Strength vs Types of Curing for M30 Mix




Average Compressive Strength vs % Variation of GGBS for M30 Mix




Average Compressive Strength of M30 Mix vs % Replacement of GGBS

## VII. CONCLUSIONS

**i)** The maximum compressive strengths 31.56N/mm$^2$ and 45.19 N/mm$^2$ were attained at 10 % replacement of cement by GGBS both for M20 and M30 mixes by Normal Curing.
**ii)** At 10% to 20 % replacement of cement by GGBS the compressive strengths are more than the target mean strengths for M20 mix . At 30 % replacement of cement by GGBS the compressive strength is less than the target mean strengths for M20 by 9.88 %
**iii)** At 10% to 20 % ,30 % replacement of cement by GGBS the compressive strengths are more than the target mean strengths for M30
**iv)** There is an increase in compressive strength up to 20% replacement of cement by GGBS by about 8.86% and 7.54 % i.e. 30.59 N/mm$^2$ and 42.22 N/mm$^2$ in normal curing for both M20 and M30 mixes respectively.

| Method of Curing | Average Compressive Strength of Cubes ( N/ mm$^2$) | | | |
|---|---|---|---|---|
| | M30 + 0% GGBS | M30 + 10% GGBS | M30 + 20% GGBS | M30 + 30% GGBS |
| Normal Curing | 39.26 | 45.19 | 42.22 | 38.89 |
| Warm Water Curing | 18.22 | 22.52 | 20.96 | 19.56 |
| Boiling Water Curing | 20.52 | 23.04 | 21.48 | 20.07 |

**v)** There is an marginal difference of in compressive strength for 30% replacement of cement by GGBS by about 9.88 % less for M20 mix and 3.94 % gain for M20 mix
**vi)**the compressive strengths achieved by boiling water curing method 17.33 n/mm$^2$ is higher than the warm water curing method is 15.56n/mm$^2$ for m20 mix.
**vii)** the compressive strengths achieved by boiling water curing method 22.22 n/mm$^2$ is lesser than the warm water curing method is 22.52 /mm$^2$ for M30 mix.
**viii)** The variation of strength by warm water curing and boiling water are 46.5% and 54.5% respectively of that of conventional curing method.
**ix)**The test results in accordance with the relevant code i.e. around 50%.

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