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# Partial Replacement of Cement by GGBS in Cement Concrete

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**ABSTRACT**

Ground Granulated Blast Furnace Slag is a by-product waste generated while producing iron. It is off white in colour and has similar cementitious properties like cement. Thus use of supplement materials is good for environment as manufacturing cement liberates a lot of carbon-dioxide. Hence, there is a constant search for supplement material. This article is all about study of compressive strength of M30 concrete (Design mix) prepared by Ordinary Portland cement (Dalmia) 53 garde, partially replaced by GGBS in 0%, 10%, 20%, 30% proportions and further comparisons will be done.

**Keywords :** GGBS, OPC, Mix-Design, compressive strength.

## I. INTRODUCTION

Save environment! We often listen or read these words in our day to day life. But the main question is that any steps are taken by us in favour to save environment. We all must join hands to save our beloved environment, and thus many such initiatives were taken like Cauvery Calling etc. As we know that concrete is the most used material on Earth after water. Thus it plays a vital role in developing civilization, concrete is used from classical civilizations till now only difference is the binding agent . Some used Gypsum, some lime later volcanic ash or old brick and tiles were added to improve setting parameters of cement. Later we used Portland cement. Cement production or manufacturing is an exhaustive energy process, which emits a lot of greenhouse gases which we know harms our environment. Also the raw materials used for the cement production is depleting thus the cost of cement is increasing year after year.

Thus the use of waste material in the most used material that is concrete has significant good impacts on environment but the material should be such type of waste which has cementitious properties like cement which can be partially replaced and not much difference is encountered in the properties. So many researches are done in order to save the environment as lot of emissions would be reduced and further the waste is also utilized properly. Here comes ground granulated blast furnace slag (GGBS) in picture which has very similar composition of cement and also is a waste by-product from iron making industry.

As we know that one tonne of cement manufacturing liberates 0.95 tonne of carbon dioxide equivalent whereas GGBS is just a by-product which is considered as a waste. GGBS is obtained in blast furnace of iron making industry in which molten iron slag is quenched in water to produce GGBS. In this study, attempt is made to study the properties of concrete after using GGBS partially for M30 grade of concrete cubes.

## II. LITERATURE REVIEW

A.H.L Swaroop, K. Venkateshwararao and P. Kodandaramarao (2013) experimental results showed that GGBS offers more resistance than fly ash in case of weight loss. They evaluated the changes in compressive strength and weight reduction in five different mixes of M30 grade and in different proportions of partial replacement by fly ash and GGBS for 7 days, 28 days, 60 days. From the study they found that the early strength is less in fly ash and GGBS concrete

with respect to conventional concrete and results of fly ash and GGBS concretes is more than conventional concrete at the end of 28 days.

Arivalagan. S (2014) incorporated GGBS with cement with 20%, 30%, 40% partial replacement of OPC with GGBS for a mix design of M35 for 7 days and 28 days and concluded that 20% replacement is optimum and cost-effective as it is waste.

Yogendra O Patil, P. N. Patil, Arun Kumar incorporated the blast furnace slag which is waste product from iron industry. They used it as partial replacement of cement n concrete as it has cementititous property. They prepared several proportions ranging from 0% to 40% partial replacement by GGBS. It is observed 20% replacement of cement is optimum without compromising much the compressive strength at 90 days.

ReshmaRughooputh and JaylinaRana (2014) investigated the effects of GGBS partially replaced with cement on concrete cubes including tensile strength, flexure and splitting strength and most important compressive strength. The percentage dry shrinkage was a slight increase with GGBS and also those cubes failed the initial surface absorption test confirming the decrease in the permeability of GGBS concrete. Also they found that workability improves but plastic density decrease with partial replacement by GGBS. Based on result the optimum mix was one with 50% OPC and 50% GGBS.

K.V. Pratap and M. Bhaskar (2014) noticed the triple blending of cement concrete with fly ash and ground granulated blast furnace slag. They conducted compressive strength and flexural strength on M60 grade with partial replacement of cement with fly ash and GGBS. They concluded increase in the compressive strength and split tensile strength at 28 days with (4+16)% replacement.

## III. MATERIALS

### A. Cement

In thepresent work Dalmia cement of 53 grade Ordinary Portland Cement (OPC) is used for casting cubes for all mixes. The cement is uniform in colour and without lumps. The properties of OPC used are below in Table 3.1

**Table 1:** Cement Properties

| Particulars | Experimental Results | IS limits (IS : 8112-2013) |
|---|---|---|
| Specific Gravity | 3.15 | - |
| Initial Setting Time | 75min | Not less than 30 minutes |
| Final Setting Time | 330min | Not more than 600 minutes |

### B. Fine Aggregates (F.A.)

The sand is locally procured and conformed to Zone II of grading as per IS 383-2016. The specific gravity of sand is 2.64. And the water absorption is found to be 1.26%.

**Table 2:**F.A. Properties

| Properties of F.A. | Results |
|---|---|
| Specific Gravity | 2.64 |
| Grading Zone | II |
| Water absorption | 1.26% |

### C. Coarse Aggregate (C.A.)

Locally available coarse aggregate is used and the maximum size used is 20mm. The specific gravity of C.A. is 2.7. And the water absorption is 0.58%.

**Table 3:** C.A. Properties

| Properties of C.A. | Results |
|---|---|
| Specific Gravity | 2.7 |
| Maximum Size | 20mm |
| Water absorption | 0.58% |

### D. Ground Granulated Blast Furnace Slag (GGBS)

GGBS is procured from Bokaro Steel Plant which is located in Bokaro District of Jharkhand. It is off- white in colour as shown in figure.

**Figure 1:** GGBS

**E. Water**

Potable tap water is used.

## IV. EXPERIMENTAL PROGRAMME

The design mix of cement concrete is done as per the procedure mentioned in the IS 10262:2009. Cubes are prepared in the proper proportions varying from 0% to 30% GGBS and compared with plain cement concrete cubes. The partial replacement is done on weight basis. And the mix proportion is 1:1.6136:2.8099 and w-c ratio is taken as 0.45 for all the mixes. The result of the ,mix design of the concrete (for 1 $m^3$) is shown in the table 4.1.

a. Grade of design= M30
b. Type of cement= OPC53 (Dalmia)
c. Maximum nominal size of aggregate= 20mm
d. Minimum cement content =300Kg/$m^3$ (IS456:2000)
e. Maximum water to cement ratio=.5(IS456:2000)
f. Exposure condition=Moderate
g. Method of concrete placing=non pumping
h. Degree of supervision= Good
i. Type of aggregate = Crushed angular aggregate
j. Workability= 75 (IS456:2000)
k. Maximum cement content=450Kg/$m^3$(IS456:2000)
l. Chemical admixture=No
m. Specific gravity of cement=3.15
n. Specific gravity of river sand= 2.64
o. Specific gravity of course aggregate=2.7

**Table 4:** Mix For Compressive Strength

| Particulars | Plain Cement Concrete | 10% | 20% | 30% |
|---|---|---|---|---|
| Cement (kg/$m^3$) | 413.33 | 372 | 330.67 | 289.34 |
| Sand (kg/$m^3$) | 666.96 | 666.96 | 666.96 | 666.96 |
| Coarse Aggregate (kg/$m^3$) | 1161.44 | 1161.44 | 1161.44 | 1161.44 |
| GGBS (kg/$m^3$) | 0 | 41.33 | 82.66 | 123.99 |
| Water (kg/$m^3$) | 186 | 186 | 186 | 186 |

Here 24 cubes are tested. The cubes having dimension of 150mm x 150mm x 150mm are prepared compressive strength of the concrete mix is calculated for 7 days and 28 days of curing. All the cubes are tested as per IS specifications and norms. Testing is done in Hand operated Compression Testing Machine (CTM).

**Figure 2:** Cubes For Testing

## V. RESULTS

The compressive strength of the concrete cubes of various proportions of partial replacement of cement by GGBS at the age of 7 days and 28 days with M30 grade of concrete with Dalmia OPC 53 grade given in table 5.1.

**Table 5:** Compressive Strength Of Mix

| Concrete Types | Compressive Strength | |
|---|---|---|
| | 7 Days (N/mm2) | 28 Days (N/mm2) |
| 100% OPC , 0%GGBS | 26.05 | 42.21 |
| 90% OPC , 10%GGBS | 21.81 | 38.03 |
| 80% OPC , 20%GGBS | 22.44 | 40.58 |
| 70% OPC , 30%GGBS | 22.24 | 39.16 |

**Figure 3:** Testing Of Cubes On CTM

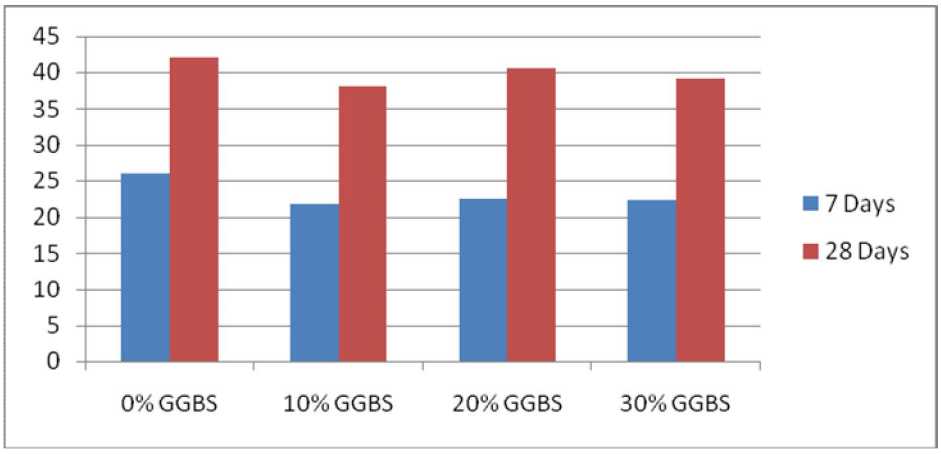


**Figure 4:** Graph of Compressive Strength At 7Days and 28Days

## VI. DISCUSSION

This study is done to get the best suitable partial replacement of cement by GGBS and have several proportions is made from 0%, 10%, 20%, 30% and there compressive strength is calculated after 7 days and 28 days and the results can be seen with the help of column chart, the results shows maximum suitability for the aim is 20% partial replacment of cement by GGBS withour much impacting the compressive strength in comparison to the 100% OPC (0% GGBS). Hence the optimum replacement as per study is 20% without changing much the compressive strength in M30 grade concrete.

## VII. CONCLUSION

The increase of GGBS content in concrete decreases the compressive strength of concrete but partial replacement of 20% can be considered as the compressive strength value is near to plain cement concrete.

The use of GGBS in concrete is economical as this is considered as a waste which comes from the iron industry. And thus reduction in cost, environmental friendly and resistant to chemical attack.

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