

# International Journal of Innovative Research in Science, Engineering and Technology

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## Compressive Strength of Concrete with Partial Replacement of Fine Aggregates with GGBFS and Glass Waste

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**ABSTRACT:** Many experimental investigation and research studies are the order of the day to enhance the performance of concrete by improving the mechanical properties such as compressive strength, split tensile strength etc. The focus of such studies is to carry out mixing of other waste materials like granite waste, marble waste, rice husk, ash, other waste etc. duly replacing one of the basic ingredients. These materials are basically the by-products of main material or some industrial-waste, which is difficult to absorb by the nature due to its chemical and physical properties. In this endeavour, a study has been carried out to investigate the change in compressive strength of concrete by replacing fine aggregates with Ground granular blast furnace slag (GGBFS) and float glass waste. The compressive strength of M25 concrete was studied by replacing fine aggregates with GGBFS to the extent of 70% in increments of 10% and with combination of GGBFS and float glass in different proportions. The compressive strength in both cases was found to enhance with optimum replacement levels as 50% of GGBFS, and combination of 8% of float glass and 50% of GGBFS. Further work in this area is suggested towards investigation of long term strength gain, other mechanical properties of concrete along with study of durability aspects.

**KEYWORDS:** GGBFS, Glass Waste, concrete, float glass, industrial waste.

### I. INTRODUCTION

Fine aggregates play a very important and essential role in the mixing of concrete. According to a survey the global use of fine aggregates is too high, to accomplish this necessary demand some other material, having the same properties as fine aggregates are widely used in now days. Concrete is a mixture of cement, aggregates, water, etc. which are easily available everywhere.

In concrete coarse aggregates are bounded together with cement and fine aggregate which fills the space and voids between two aggregate. The rapid growth of industrialization in the world is giving birth to various kinds of wastes which are very dangerous to our environment. And it needs its proper utilization. GGBFS is a by-product of iron and steel industry. In blast furnace slag, float to the top of iron and removed. GGBFS is produced through quenching the molten slag in water and then grinding it into fine power form as per requirement. One of the best ways to utilization of Ground Granulated Blast Furnace Slag and glass waste produced from industry is in replacement of fine aggregate in concrete. Ground Granulated Blast Furnace Slag is produced from iron industry after the removal of molten iron. Slag is a non-metallic inert waste consisting of mainly silicates, alumina silicates and calcium-alumina-silicates. Whereas glass is non-biodegradable material produced by melting a mixture of materials such as silica, soda ash, and CaCO<sub>3</sub> at high temperature followed by cooling where solidification occurs without crystallization. Glass widely used in our lives through manufactured products such as sheet glass, bottles, glassware, and vacuum tubing. So that a very large amount of glass waste is produced every day and it need its proper utilization.

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When ground granular blast furnace slag is replaced with fine aggregate at 50% it gives the maximum strength for that case. And when fine aggregate is replaced with 50% ground granular blast furnace slag along with glass waste replacement as 2%, 4%, 6%, 8%, 10% and at 12% simultaneously with fine aggregate. Then there is decrease in the weight of concrete, increase in strength as compare to conventional concrete, and it becomes more economical.

## II. LITERATURE REVIEW

**MHRD Survey [1][2017]:** About 50-100 tons of GGBFS is produced daily from steel and iron industry.

**Gaurav Singhet.al. [2][2015]:** Many researches are performing to find the accurate property of GGBFS at its chemical and physical characteristics. In this study fine aggregate is replaced with GGBFS with an incremental increase of 10%, upto 100%. When strength of concrete is measured after 28 days curing, Strength of concrete increases proportionally up to 50% replacement and after that (increase in its percentage that leads to decrease in concrete strength (Strength efficiency factor varies from 1.29 to 0.70 for replacement of 10% to 80 %). It also improves the workability of concrete by mixing the ratio of 10 to 80%. Laboratory investigation shows that optimum level of GGBFS on the compressive strength of concrete. The test results proved that the compressive strength of concrete mixtures containing GGBFS increases. At an optimum point of 50% replacement, the addition of GGBS does not improve the compressive strength. The early strength of GGBFS concretes was lower than the control concretes. As the curing period is increased the strength increase was higher for the GGBFS concrete.

**Ishan Srivastava et.al. [3][2017]:** The glass is a transparent material which is produced by melting of materials like silica, soda ash, and  $\text{CaCO}_3$  at high temperature after cooling solidification occurs without crystallization. In this study it shows that one of the great use of glass waste is in the construction field where the waste glass was reused for concrete. In this studies it have shown that waste glass which is crushed and used in concrete gives the strong, safe and economical alternative to replace of fine aggregates in concrete. In this study fine aggregate is replaced with glass waste from 0% to up to 40% with an incremental increase of 10%. After curing of concrete cube for 28 days, the test result shows that there is increase in strength of concrete when fine aggregate is replaced up to the 20% and after that if there is an increase in percentage of glass then there is decrease in its strength. The laboratory result shows that the replacement of fine aggregate up to 20% gives the better result as compare to convention concrete.

**S.P. Gautam et.al [4][2012]:** This study is based on the Glass waste, its physical and chemical properties. In this study fine aggregate is replaced by the glass waste in order to increase the strength of concrete. In this study fine aggregate is replaced with Glass waste with an incremental increase of 10%, up to 50%. When strength of concrete is measured after 28 days after curing, Strength of concrete increases proportionally up to 10% replacement and then at 20% replacement strength of concrete slightly reduces. While using waste glass as fine aggregate in concrete the 28 day strength is found to marginally increase up to 20% replacement and marginal decrease in strength is observed at 30% to 40% replacement level of waste glass. The result shows that the compressive strength of concrete mixtures containing Glass increase up to a specific point of replacement in concrete. The optimum replacement level of glass waste as fine aggregate which is used in concrete is 10%.

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## III. MATERIAL USED

### 1. Cement

Portland Pozzolonic Cement was used in this study conforming to IS: 1489.

Test performed on the cement are tabulated in the table below.

| Sl.No | Test name            | Values obtained |
|-------|----------------------|-----------------|
| 1     | Specific gravity     | 3.17            |
| 2     | Standard consistency | 28%             |
| 3     | Initial setting time | 47 minutes      |
| 4     | Final setting time   | 303 minutes     |

### 2. Fine Aggregate

As per Indian Standards if the aggregate size is between 150 microns to 4.75mm is termed as fine aggregates. The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent.

Test performed on the fine aggregates are tabulated in the table below.

| Sr.No | Properties       | Result          |
|-------|------------------|-----------------|
| 1     | Specific gravity | 2.79            |
| 2     | Fineness modulus | 3.178 (Zone II) |
| 3     | Water absorption | 2.8%            |

### 3. Coarse Aggregate

As per Indian Standard size of is grater then 4.75 mm is termed as coarse aggregates. Commonly-used coarse aggregates in concrete are gravels and pebbles.

Test performed on the coarse aggregates are tabulated in the table below

| Sr.No | Properties       | Values obtained |
|-------|------------------|-----------------|
| 1     | Specific gravity | 2.4             |
| 2     | Abrasion value   | 15%             |
| 3     | Water absorption | 0.79%           |
| 4     | Impact value     | 11.27%          |

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## 4. Ground Granular Blast Furnace Slag (GGBFS)

GGBFS is produced through quenching the molten slag in water and then grinding it into fine power form as per requirement. GGBS is used to make durable concrete structures in combination with ordinary Portland cement and/or other pozzolanic materials.



### Advantages

- Reduction of CO<sub>2</sub>, NO<sub>2</sub> emission
- Efflorescence is less
- Permeability is less
- High workability

## 5. Water

Portable clean water is used in this study for both the purposes (curing and casting). Water absorbed by aggregates is not include from the mixing of water. The water pay an important role in the batching and mixing of concrete and make changes in the property of freshly prepared concrete and conventional materials.

## 6. Glass waste

Glass is non biodegradable material produced by melting a mixture of materials such as silica, soda ash, and CaCO<sub>3</sub> at high temperature followed by cooling where solidification occurs without crystallization.

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## Advantages

- Hardness and brittleness
- Good compressive strength
- No efflorescence
- Weather resistant
- chemical resistant

## IV. MIX PROPORTION

M25 grade of concrete is formed by the conventional material and the water cement ratio was adopted as 0.45. After that fine aggregate is replaced with GGBFS and Glass waste. The quantities of ingredients for 1 cum. of concrete with and without replacements areas given below:

### Fine Aggregate (Sand) replacement with GGBFS

| S.no | Cement (kg) | Corse Aggregates (kg) | Sand (%) | Sand (Kg) | GGBFS (%) | GGBFS (Kg) |
|------|-------------|-----------------------|----------|-----------|-----------|------------|
| S1   | 558         | 1116                  | 100      | 558       | 0         | 0          |
| S2   | 558         | 1116                  | 90       | 502.2     | 10        | 55.8       |
| S3   | 558         | 1116                  | 80       | 446.4     | 20        | 111.6      |
| S4   | 558         | 1116                  | 70       | 390.6     | 30        | 167.4      |
| S5   | 558         | 1116                  | 60       | 334.8     | 40        | 223.2      |
| S6   | 558         | 1116                  | 50       | 279       | 50        | 279        |
| S7   | 558         | 1116                  | 40       | 223.2     | 60        | 334.8      |
| S8   | 558         | 1116                  | 30       | 167.4     | 70        | 390.6      |

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**Effect of Glass waste after optimization with GGBFS:**

| S.no | Cement | Coarse aggregate | Fine aggregate (Sand) | Water |
|------|--------|------------------|-----------------------|-------|
| 1    | 558kg  | 1116Kg           | 558kg                 | 251kg |

In this study results shows that replacement of fine aggregate using 50% ground granular blast furnace slag powder shows higher compressive strength. So the next optimization was carried out using 50% ground granular blast furnace slag and varying percentages of Glass waste. The variation of glass waste is by the 2% incremental increase level.

**Fine Aggregate(Sand + GGBFS) replacement with Glass waste**

| S.no | Cement (kg) | Corse Aggregates (kg) | (Sand+GGBFS) (%) | (Sand+GGBFS) (Kg) | Glass (%) | Glass (Kg) |
|------|-------------|-----------------------|------------------|-------------------|-----------|------------|
| 1    | 558         | 1116                  | 96               | 535.68            | 4         | 22.32      |
| 2    | 558         | 1116                  | 94               | 524.52            | 6         | 33.48      |
| 3    | 558         | 1116                  | 92               | 513.36            | 8         | 44.64      |
| 4    | 558         | 1116                  | 90               | 502.2             | 10        | 55.8       |
| 5    | 558         | 1116                  | 88               | 491.04            | 12        | 66.96      |

## V. RESULT AND DISCUSSION

### • Compressive Strength

In study it has been observed that when the fine aggregate is replaced with ground granular blast furnace slag there is increase in compressive strength. Up to 50% replacement of fine aggregate with ground granular blast furnace slag there is an increase in compressive strength of concrete and after that the strength progressively decreases.

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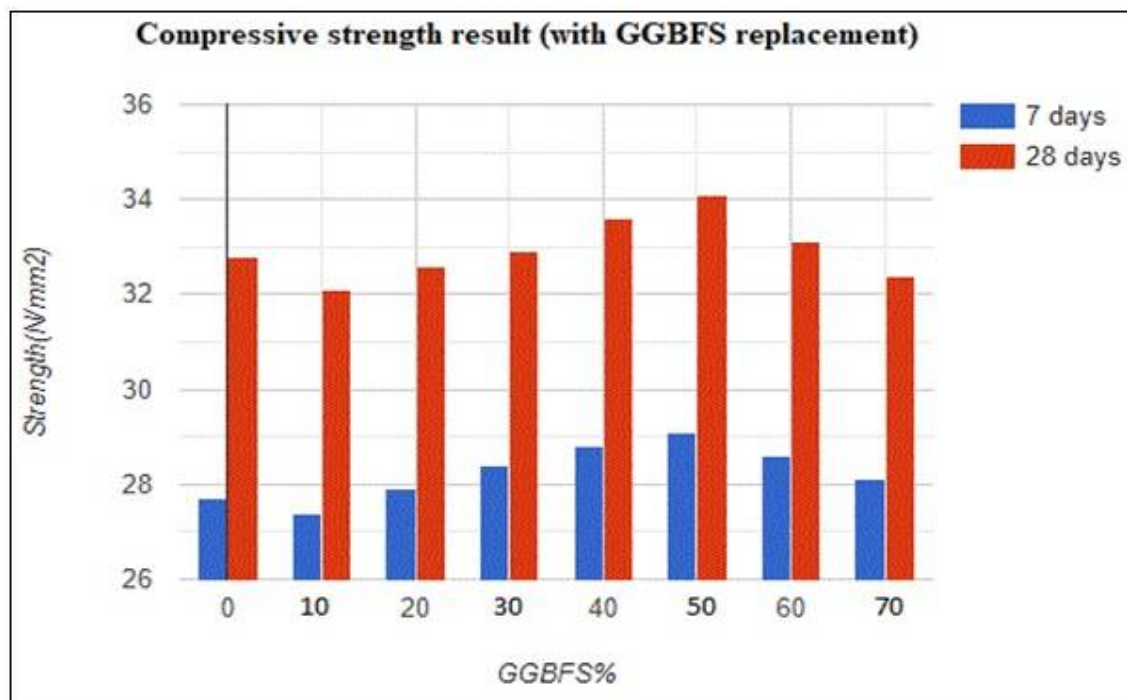
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- Fine aggregate replacement with GGBFS

| Sample No | 7 <sup>th</sup> Day Compressive Strength<br>(N/mm <sup>2</sup> ) | 28 <sup>th</sup> Day Compressive Strength<br>(N/mm <sup>2</sup> ) |
|-----------|------------------------------------------------------------------|-------------------------------------------------------------------|
| S1        | 27.8                                                             | 32.8                                                              |
| S2        | 27.4                                                             | 32                                                                |
| S3        | 27.9                                                             | 32.5                                                              |
| S4        | 28.4                                                             | 32.9                                                              |
| S5        | 28.8                                                             | 33.7                                                              |
| S6        | 29                                                               | 34.1                                                              |
| S7        | 28.7                                                             | 33.1                                                              |
| S8        | 28.1                                                             | 32.3                                                              |



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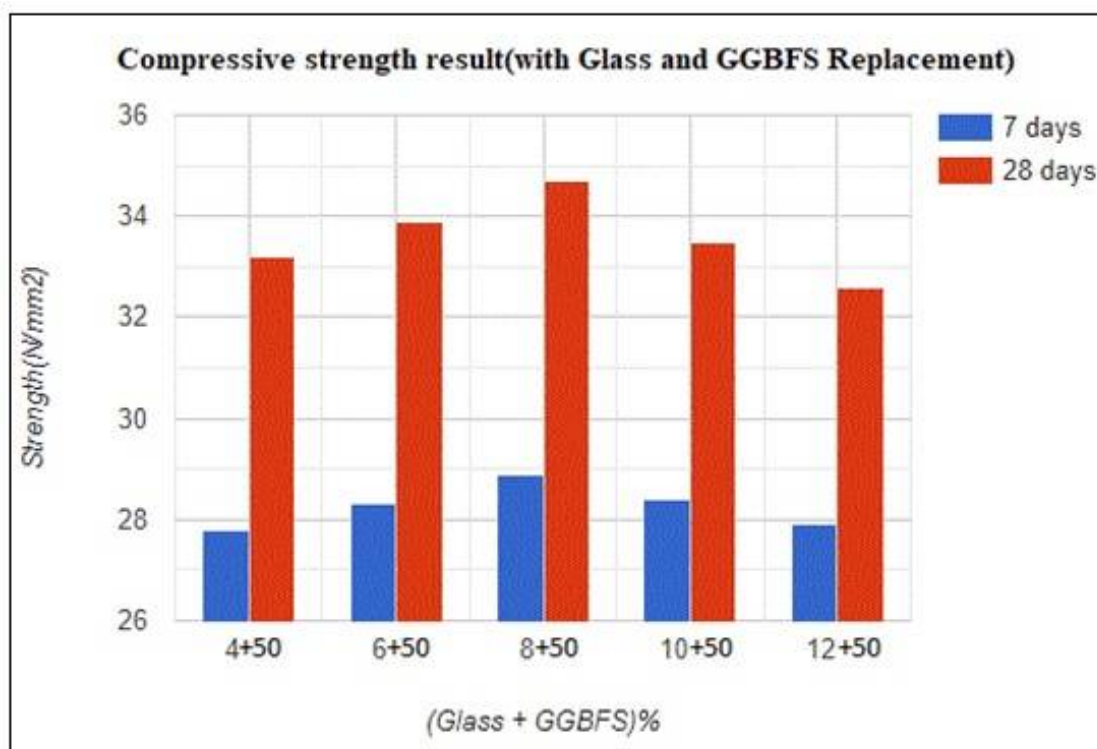
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- Fine aggregate(Sand + GGBFS) replacement with Glass waste

| Sample no | 7 <sup>th</sup> Day Compressive strength<br>(N/mm <sup>2</sup> ) | 28 <sup>th</sup> Day Compressive strength<br>(N/mm <sup>2</sup> ) |
|-----------|------------------------------------------------------------------|-------------------------------------------------------------------|
| 1         | 27.8                                                             | 33.2                                                              |
| 2         | 28.3                                                             | 33.8                                                              |
| 3         | 28.8                                                             | 34.7                                                              |
| 4         | 28.4                                                             | 33.5                                                              |
| 5         | 27.9                                                             | 32.6                                                              |



- Evaluation of Compressive Strength

In study it has been observed that the compressive strength of concrete replaced with Ground granular blast furnace slag and Glass waste increases as the amount of replacement increases up to a certain percentage (50%GGBFS+ 8% glass waste in this present study). Up to 8% replacement of Glass waste an increase in strength was observed, after that compressive strength start decreasing. The Concrete mix is 50% replacement of fine aggregate with ground granular

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blast furnace slag and 8% glass waste showed an increase in compressive strength by 10.46%. The compressive strength of fine aggregate replaced with ground granular blast furnace slag and Glass waste is shown below.

## **VI. CONCLUSION**

Some of the important findings of the study are:

- The compressive strength of concrete increases with increase in GGBFS and Glass percentage up to a certain percentage and after that it decreases.
- Based on experimental studies 50% GGBFS and 8% glass waste substitution generally results in best favorable outcomes for compressive strength.
- The use of GGBFS and float glass at the expense of fine aggregate can lead to reduction in the cost of concrete provided long term results are also obtained on similar lines and durability of concrete ascertained along with other mechanical properties of concrete.

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