

Experimental Study on Partial Replacement of Cement by GGBS and Fine Aggregate by Foundry Sand for M30 Grade Concrete

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Abstract - Now a days good quality natural river sand is not readily available, it is to be transported from a long distance. These resources are also exhausting very rapidly. So there is a need to find alternative to natural river sand, As a substitute to natural sand by artificial sand(foundry sand) is used and cement by GGBS as a partial replacement. The behavior of concrete is assured by partially replacing the natural river sand with foundry sand and cement with GGBS both are industrial byproducts produced from iron industries. Use of GGBS and Foundry sand does not only reduce the construction cost but also helps to reduce the impact on environment by consuming the material generally considered as industrial waste products. The experimental work is mainly concern with the study of physical properties like compressive strength of concrete by partial replacement of cement with GGBS and natural river sand by foundry sand as fine aggregate. The cement has been replaced by GGBS in the range of 0%, 5%, 10%, 15%, 20% & 25% by weight of cement. The sand has been replaced by Foundry sand in the range of 0%, 10%, 20%, 25% & 30% by weight of sand for every replacement of GGBS for M30 grade mix. Concrete cubes were casted and tested after 7 days & 28 days of curing for compressive strength and compared with the conventional concrete specimens. So that optimum percentage of GGBS and Foundry sand are to be determined.

Key Words: Ground Granulated Blast Furnace Slag (GGBS), Foundry Sand (FS), Natural River Sand, Ordinary Portland Cement (OPC), Compressive Strength

1. INTRODUCTION

The concrete blocks have been used in several developing countries including Sri Lanka over an extensive period of time. Concrete which is being broadly used in the construction industry has infinite opportunities for innovative applications design and construction methods. Factors such as strength, workability and durability of the ordinary concrete are always being modified to make it more suitable for a specified construction purpose. This becomes more realistic due to the advancement of technology. Some studies have been carried out to identify substitutes for fine aggregates and for cement in manufacturing concrete products that would enhance the properties while reducing the cost

2. MATERIALS AND METHODOLOGY

- 1. Cement:** Ordinary Portland Cement (OPC) 43 grade (Ultratech) cement was used. Which is fresh and without any lumps. Some of the tests have been conducted in the laboratory to know the properties of cement. The testing of cement was as per IS: 8112-1989.

Table 1: Test results on Cement

| SI.NO | Particulars | Test Results |
|-------|------------------------|--------------|
| 1 | Initial setting time | 48 minutes |
| 2 | Final setting time | 385 minutes |
| 3 | Normal consistency (%) | 29% |
| 4 | Specific gravity | 3.01 |
| 5 | Soundness test | 2mm |
| 6 | Fineness | 3% |

- 2. Fine aggregate:** Locally available natural river sand is used as Fine aggregates. The sand passing through 4.75 mm size IS sieve is used in the preparation of specimens. As per IS: 383-1970 recommendation. The results have been tabulated in table 2.

Table 2: Test Results of Fine Aggregate

| | |
|---------------------------------|--------|
| Fineness Modulus | 3.14 |
| Specific Gravity | 2.6 |
| Grading Zone as per IS:383-1970 | Zone-I |

- 3. Coarse aggregate:** The coarse aggregate used in the present investigation are locally available crushed stone aggregates were collected from the quarry. The aggregates having 20mm down and 12.5mm down size are used as coarse aggregates in this experiment. Both 20mm down and 12.5mm down size aggregates are mixed in equal proportion and tested as per IS:383-1970. The test result of coarse aggregate as tabulated table 3.

Table 3: Test results of coarse aggregates

| | |
|------------------|----------------------|
| Specific Gravity | 2.725 |
| Shape Size | Angular |
| Size | 20mm and 12.5mm down |

4. Ground Granulated Blast Furnace Slag (GGBS) :

GGBS is a byproduct obtained by quenching molten iron slag from iron and steelmaking industries of blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. GGBS is used to make durable concrete structures in blending with ordinary Portland cement and or pozzolanic materials. GGBS is collected from Ulmani Constructions, Harihara Industrial area, Davanagere district. The test results have been tabulated in tablt 4.

Table 4: Test Results of GGBS

| | |
|------------------|-------------|
| Colour | white |
| Appearance | fine powder |
| Fineness | 4% |
| Specific Gravity | 3.05 |

5. Foundry Sand (FS): *Foundry sand is high quality silica sand with uniform physical characteristics. It is a byproduct obtained from the production of ferrous and nonferrous metal in casting industries, where sand has been used for centuries as a molding material because of its thermal conductivity. And was collected from Indian Trade Links. Harihara Industrial area, Davanagere district. The test results of Foundry sand is tabulated in table 5.*

Table 5: Test results of foundry sand

| | |
|------------------|-------|
| Colour | Black |
| Fineness modulus | 3.02 |
| Specific Gravity | 2.5 |

6. Water: Water is an essential constituent of concrete as it actively contributes in the chemical reaction with cement. The water which is used for making concrete should be clean, fresh and free from organic matter and harmful impurities such as oil, alkali, acids etc. The PH value should not less than 6. The water used for casting and curing of concrete should satisfy as per IS 456-2000.

7. Super Plasticizer: In the current experimental work Conplast SP430 is used as super plasticizing admixture. Conplast SP430 is based on Sulphonated Naphthalene polymers and supplied

as a brown liquid instantly dispersible in water. Its specific gravity is 1.220 to 1.225 at 30°C

3. METHODOLOGY: The fundamental tests are conducted on OPC43 grade cement, GGBS, foundry sand, Fine aggregate and Coarse aggregate to check their suitability for making concrete. The cubes (150x150x150mm size) were casted based on mix proportions. Conventional method of batching and mixing was done. The cement has been replaced by GGBS accordingly in the range of 0%, 5%, 10%, 15%, 20% and 25% by weight of cement. The Fine aggregate has been replaced by foundry sand accordingly in the range of 0%, 10%, 20%, 25% and 30% by weight of fine aggregate for every replacement of GGBS for M30 grade mix. Concrete cubes were casted and tested after 7days and 28 days curing for compressive strength and compared with normal concrete specimens. So that optimum percentage of GGBS and foundry sand are to be determined. The casted cubes were left undisturbed in laboratory along with mould for 24 hours. Then the cubes were demoulded after 24 hours and were placed in curing tank for 28 days of curing. The experimental work is divided in to 6 iterations. Each iterations has constant GGBS replacement for cement and varying foundry sand replacement for fine aggregate in the range 0% to 30%. Different combination of replacement ratios of GGBS and foundry sand are tabulated below table6.

Table 6: Combination of Replacement ratios of GGBS and Foundry Sand:

| SL. NO | GGBS % Replacement with cement | Foundry sand % Replacement with Fine Aggregate | | | | |
|--------|--------------------------------|--|----|----|----|----|
| | | 0 | 10 | 20 | 25 | 30 |
| 1 | 0 | 0 | 10 | 20 | 25 | 30 |
| 2 | 5% | 0 | 10 | 20 | 25 | 30 |
| 3 | 10 % | 0 | 10 | 20 | 25 | 30 |
| 4 | 15% | 0 | 10 | 20 | 25 | 30 |
| 5 | 20% | 0 | 10 | 20 | 25 | 30 |
| 6 | 25% | 0 | 10 | 20 | 25 | 30 |

For each iteration, two sets of cubes (6 specimens) were casted. One set of cubes were tested for compressive strength after 7 days of curing and other set of cubes were tested after 28 days of curing.

4. MIX DESIGN: The M30 grade of concrete is adopted for the present Experimental work. Detailed mix proportion is obtained as per IS: 10262-2009.

Table 7: Mix proportion

| Ingredients | Water in liters | Cement in Kg | Natural River sand in Kg | Coarse aggregate in Kg | |
|---------------------|-----------------|--------------|--------------------------|------------------------|---------------|
| | | | | 20 mm (50%) | 12.5 mm (50%) |
| Quantity | 161.82 | 380.75 | 640.38 | 630.3 | 630.3 |
| Mix ratio by weight | W/C = 0.425 | 1 | 1.558 | 1.655 | 1.655 |

| | | | |
|----|--------------|--------------|--------------|
| 24 | 20+25 | 42.96 | 52.29 |
| 25 | 20+30 | 27.85 | 31.85 |
| 26 | 25+0 | 33.63 | 40.74 |
| 27 | 25+10 | 32.59 | 40.59 |
| 28 | 25+20 | 30.96 | 35.70 |
| 29 | 25+25 | 29.92 | 33.63 |
| 30 | 25+30 | 25.78 | 30.67 |

5. RESULTS AND DISCUSSIONS

The Compressive Strength results of 7 days and 28 days are tabulated for different replacement ratios for M30 grade concrete mix. The results are tabulated as varying replacement for fine aggregate with restricted replacement for cement.

Table 8: Compressive Strength of concrete

| SL. NO | Mix (GGBS+FS) in % | Compressive Strength (Mpa) | |
|--------|---------------------|----------------------------|--------------|
| | | 7 days | 28 days |
| 1 | conventional | 29.33 | 38.22 |
| 2 | 0+10 | 32.59 | 37.78 |
| 3 | 0+20 | 35.56 | 38.67 |
| 4 | 0+25 | 37.48 | 44.89 |
| 5 | 0+30 | 29.62 | 31.26 |
| 6 | 5+0 | 31.85 | 40.44 |
| 7 | 5+10 | 36.74 | 42.67 |
| 8 | 5+20 | 37.33 | 41.03 |
| 9 | 5+25 | 38.96 | 48.59 |
| 10 | 5+30 | 27.40 | 32.44 |
| 11 | 10+0 | 32.89 | 38.51 |
| 12 | 10+10 | 30.52 | 40.44 |
| 13 | 10+20 | 36.44 | 42.67 |
| 14 | 10+25 | 39.70 | 44 |
| 15 | 10+30 | 25.63 | 32.74 |
| 16 | 15+0 | 36.29 | 41.92 |
| 17 | 15+10 | 31.85 | 40.14 |
| 18 | 15+20 | 37.63 | 43.40 |
| 19 | 15+25 | 41.18 | 45.18 |
| 20 | 15+30 | 27.11 | 34.22 |
| 21 | 20+0 | 37.78 | 44 |
| 22 | 20+10 | 36.29 | 44.74 |
| 23 | 20+20 | 38.81 | 48.89 |

Optimum Compressive strength of concrete: The results of compressive strength of concrete cubes for 7 days and 28 days are tabulated for varying % replacement of cement by GGBS & varying % replacement of Fine aggregate (Natural river sand) by Foundry sand for optimum mix. It is observed that the optimum compressive strength for 7 days & 28 days are observed for 20% of replacement of the cement by GGBS and 25% of replacement of the Fine aggregate by Foundry sand.

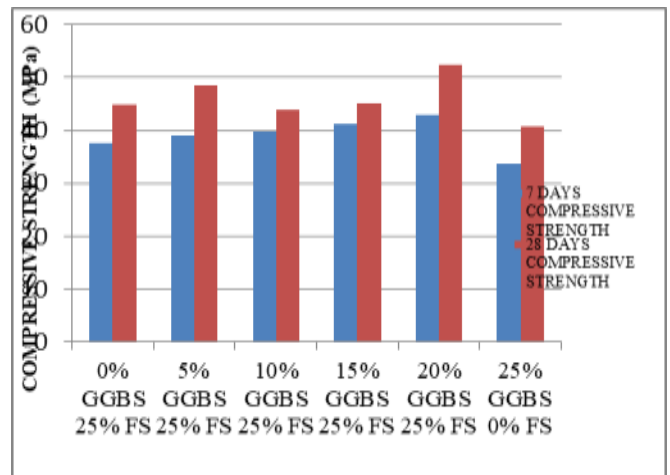


Chart -1: Graph shows the Optimum compressive strength of concrete

The concrete behavior is studied by partial replacement of cement by GGBS & Fine aggregate by Foundry sand. The following Conclusions have been taken from the obtained results.

6. CONCLUSIONS

The concrete behavior is studied by partial replacement of cement by GGBS & Fine aggregate by Foundry sand. The following Conclusions have been taken from the obtained results.

In this study, For M30 Grade of concrete the mean target strength is achieved by partial replacement of cement by GGBS and Fine aggregate by Foundry sand.

From this experimental study, The optimum replacement ratio for M30 grade of concrete mix are 20% replacement of cement by GGBS and 25% replacement of fine aggregate by

Foundry sand, which gives 36% more compressive strength than the results of conventional concrete and target strength of M30 mix.

From this experimental study, we can conclude that the use of foundry sand in concrete reduces the production of waste through metal industries. Hence its an eco-friendly building material.

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