Strength and Durability Studies on Concrete Containing Foundry Sand and GGBS

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Abstract-This research was conducted to establish the effects of GGBFS and used foundry sand on strength and durability of concrete. This project is relevant as cost of the building material is increasing and availability of the material is decreasing, which leads to many environmental issues. Sand in the concrete was replaced by foundry sand and the cement was replaced by GGBFS in different proportions. Quarry sand was replaced by0, 15, 25, 35 and 45%, and cement was replaced at a percentage of 0, 30 and 50%. The strength and durability properties of the mixes were compared with the properties of conventional concrete mix. Strength tests such as compressive strength, split tensile strength, and durability properties such as sulphate attack, and water absorption tests were carried out.From the results it can be concluded that foundry sand and GGBS can be effectively used as replacing materials in concrete.

Index Terms-Foundry sand; GGBS; Strength; Durability

1. INTRODUCTION

Concrete is the most commonly used construction material because of its low cost, availability of raw materials, strength, and durability.Nowadays there is an enhanced development in construction, thus there is an increase in cost of construction materials. It is also due to the deficiency of materials from environmental sources. So search for some other materials is important which do not cause any environmental issues. It leads to the importance of this research in which the strength and durability properties of partially replaced concrete is made into study.

Foundry sand is high quality silica sand with uniform physical characteristics. It is a by-product of ferrous and non-ferrous metal casting industries, where sand has been used for centuries as a molding material because of its thermal conductivity. Foundries recycle and reuse the sand many times in a foundry. When the sand cannot be reused in the foundry, it is removed from the foundry and is called as foundry sand. The ground granulated blast furnace slag (GGBS) is a waste product from the iron manufacturing industry which may be used as a partially replacingmaterial of cement in concrete due to its cementing properties.

2. EXPERIMENTAL INVESTIGATION

2.1. Materials

2.1.1. Cement

Portlandpozzolana cementof 53 grade available in local market was used in the whole testing. Tests were conducted on cement to determine standard consistency, initial and final setting time, and specific

gravity as per IS 4031-1988. It was confirmed that the properties of cement is according to the specifications as per IS 12269-1987.

2.1.2. Coarse aggregate

The coarse aggregate chosen for Concrete was typically angular in shape, well graded, and smaller than maximum size suited for conventional concrete. The coarse aggregate used in the experiment were of 20mm size, and were tested as per IS: 2386-1963 (I. II and III) specifications.Specificgravity of coarse aggregate was found as 2.64.

2.1.3. Fine Aggregate

Fine aggregate used for experiment was locally available quarry sand conforming to grading zone II as per IS: 383-1970, and having specific gravity of 2.5 and fineness modulus 3.83. The maximum size of fine aggregate was taken as 4.75 mm.

2.1.4. Super Plasticizer

A super plasticizer confirming to IS- 9103-1979 by trade name CONPLAST SP430 in the form of sulphonated naphthalene polymer available in local market was used.

2.1.5. Water

Portable water available from laboratory which satisfies the drinking standard is used for mixing and curing.

2.1.6. Used Foundry Sand (UFS)

The foundry sand was collected from an iron industry inKolapully, Kerala. The specific gravity of Foundry sand was found as2.3. The testing was done as per IS: 383-1970. Sieve analysis results shows that it contains a good amount of finer particles. Sand used in foundries will have a sticky property, but when it exposed to continuous heating its sticky property get vanished which makes it a waste product from foundries.

Table 1. Physical properties of UFS

Property	Results
Specific Gravity	2.3
Bulk Relative Density, kg/m ³	2589
Absorption	0.45%
Moisture content	0.1-10.1



Fig.2. Foundry sand

2.1.5 Ground Granulated Blast Furnace Slag (GGBS)

The material was collected from an industry in Mathikare near Bangalore.It has very good cementitious property and proven as a good replacing material of cement.

Table 2. Physical properties of GGBS

Particulars	Values
Color	Off white
Bulk density (Kg/l)	$1200 \text{ kg/}m^3$
Specific gravity	2.9



Fig.2. GGBS

2.2. Design Mix Methodology

A cement concrete M30 mix was designed as per IS: 10262-1982. In present study fine aggregate was replaced by foundry sand at 0, 15, 25, 35, and 45 %, and cement was replaced at 0, 30, and 50%. The same mix design was used for all the mixes. Water content was fixed as 0.45. The design mix proportion is given in table 3. Weight of materials in m³ can be given as, Cement = 377.78 kg/m^3

Fine Aggregate = 655 kg/m^3

Coarse Aggregate = 1246 kg/m^3

Water = 170 lit

water = 170 Int

Different mixed in the study are as follows

Table 3	. Types	of	concrete	mixes
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Mix	Quarr y sand (%)	Foundry sand (%)	Cement (%)	GGBS (%)
СМ	100	0	100	0
FG-15-0	85	15	100	0
FG-25-0	75	25	100	0
FG-35-0	65	35	100	0
FG-45-0	55	45	100	0
FG-15-30	85	15	70	30
FG-25-30	75	25	70	30
FG-35-30	65	35	70	30
FG-45-30	55	45	70	30
FG-15-50	15	15	50	50
FG-25-50	25	25	50	50
FG-35-50	35	35	50	50
FG-45-50	45	45	50	50

2.3 Testing Methodology

2.3.1. Test Details

Minimum three numbers of samples were made for each mix. A total number of 156 samples were made for this project. Sizes of each sample are specified in table 4.

Table 4. Size of specimens

Tests	Specimen size (mm)
Compression test	150×150×150
Split tensile test	300×150
Flexural test	100×100×500
Water absorption	150×150×150
Sulphate attack	100×100×100
Carbonation	200×100

Testing of specimens for compressive strength and flexural strength were carried out according to

IS: 516-1959. Split tensile strength was determined according to IS: 5816-1970. 28 days compressive strength and split tensile strength were determined in an automatic compression testing machine of capacity 5000 kN. The flexural strength was checked using a universal testing machine of capacity 600 kN.



Fig.3. Automatic compression testing machine

Sulphate attack test were carried out to check the compressive strength reduction of concrete cubes after 56 days immersion in 5% sodium sulphate solution. Water absorption test was carried out according to ASTM C-642-81.

RESULTSANDDISCUSSIONS

2.3. Compressive Strength

Average compressive strength of 28 days was determined and Fig.3 shows the results. As per results, the maximum compressive strength was obtained for FG-25-30 mix. The strength obtained is 42.5 MPa. It is more than control mix by5.6 %, as the compressive strength of control mix is 40.1 MPa. 50% replacement of cement with GGBS does not give strength near to control mix.



Fig.3. Compressive strength test results of various mixes

At 30% replacement of GGBS all the replacing percentages of foundry sand gives good strength which is more than target value.

2.4. Split Tensile Strength

Split tensile strength of 30% and 0% GGBS mixes and control mixes were compared, and results are as shown in Fig. 4. The maximum split tensile strength was obtained for 25% foundry sand with 30% GGBS mix and it was 3.83. Strength of 0% GGBS showed less strength than control mix. 30% GGBS mixes with 15, 25 and 35% showed results comparing to control mix.



Fig.4. Split tensile test result of various mixes

2.5. Flexural Strength

The results of flexural strength tests are as shown in Fig. 5. It says that the maximum flexural strength was obtained for optimum mix. Comparing with control mix 30% GGBS mixes showed a good strength and 0% mixes showed comparatively low value.



Fig.5. Flexural Strength test results of various mixes

2.6. Water absorption Test

Water absorption results were obtained as shown in Fig.6. It says that comparing with control mix all other mixes given a higher water absorption value. It may be due to water absorption properties of the replacing materials. But the water absorption values are within limit, and the optimum mix showed a near value to the control mix that is 2.99% while the water absorption of the control mix was 2.98%.



Fig.6. Water absorption test results of various samples

2.7. Sulphate Attack

Result of sulphate attack is as shown in Fig. 7. Many materials get attacked severely by sulphate reaction which reduces the compressive strength by a percentage. But foundry sand and GGBS has shown a good resistance to sulphate attack. It may be due to the chemical properties of the replacing materials. As the quantity of GGBS increased strength reduction decreased. But in case of foundry sand good results were obtained for 25% mix. Maximum strength reduction was seen for control mix



Fig.7. Sulphate attack



Fig.8. Specimens after sulphate attack

2.8. Carbonation

Result of carbonation test is detailed in Fig. 9. The result says that when the quantity of GGBS increases carbonation also increases. The carbonation has a slight increase with increase in quantity of foundry sand. Control mix shows a less amount of carbonation as compared with the replaced mixes. It is due to the chemical properties of materials. In the graph C is the carbonation coefficient, which is the relation between depth of carbonation and square root of duration in months. Fig. 10 shows the carbonated specimens of control mix which is less carbonated and FG-45-50 which is most effected.



Fig.9. Carbonation



Fig.10. Carbonation of CM and FG-45-50

3. CONCLUSION

From the test results we can summarize the following conclusions:

- The maximum strength was obtained for 25% foundry sand and 30% GGBS mix.
- All mixes of 30% GGBS mixes shown a good strength comparing with control mix. It is due to good packing of materials which indicates the pozzolanicproperties of GGBS provide strength to mix.
- As comparing with mixes without GGBS 30% GGBS mixes showed a good result.
- Water absorption was more in replacing material mixes as compared with control mix, but it was in the limit. So it is safe against water absorption
- The material replacing mixes showed a good resistance to sulphate attack than control mix. So these material mix can be effectively used in highly sulphate regions.
- As the percentage of GGBS increases carbonation also increases. It may be due to the chemical properties of GGBS. So it can only be used up to a limit.
- It can be concluded that replacing of fine aggregate with foundry sand is possible upto 35%, when GGBS is used to replace the cement upto 30%. Without GGBS only up to 25% replacement of fine aggregate is possible.

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