Experimental Study on Partial Replacement of Cement by GGBS and Fine Aggregate by Foundry Sand for M20 Grade Concrete

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Abstract – *The infrastructures are developing day by day demand is more for concrete. The construction activity is readily depend on concrete directly or indirectly. By this significant demand for natural resources like river sand etc., are depleting day by day and heavy release of carbon dioxide gas in cement manufacturing process, destruction of environment taking place. To overcome these problems, partial use of industrial waste in place of cement and river sand are necessary in production of concrete. In this this study an attempt has been made with M20 mix proportion. Experimental study is conducted to evaluate the strength characteristics of hardened concrete. The properties of concrete is assessed 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 impact on environment by consuming material considered as the industrial waste product. The cement has been replaced by GGBS in the range of 0%, 5%, 10%, 15%, 20% & 25% by weight of cement. The sand has been replaced by Foundry sand in the range of 0%, 10%, 20%, 25% & 30% by weight of sand for every replacement of GGBS for M20 grade mix. Concrete cubes were casted and tested after 7 days & 28 days of curing for compressive strength and compared with the compressive strength of control cubes and the optimum percentage of GGBS and Foundry sand are to be determined.*

***Key Words*: Industrial waste, Ground Granulated Blast Furnace Slag (GGBS), Foundry Sand (FS), Natural River Sand, Compressive Strength.**

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. GGBS and Foundry sand are few of industrial byproducts from iron industry which are partially replaced with cement and river sand respectively for M20 grade concrete

2. MATERIALS AND METHODOLOGY

1. **Cement**: Ordinary Portland Cement (OPC) 43 grade (Ultratech) cement confirming to (IS:8112-1989) 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 results have been tabulated in Table 1.

Table 1: Test results on Cement

SI.NO	Particulars	Test Results
1	Initial setting time	46 minutes
2	Final setting time	380 minutes
3	Normal consistency (%)	29%
4	Specific gravity	3.05
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	3.17
Specific Gravity	2.62
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	2.625
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 table 4.

Table 4: Test Results of GGBS

Colour	white
Appearance	fine powder
Fineness	3%
Specific Gravity	3.0

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, Davangere district. The test results of Foundry sand is tabulated in table 5.

Table 5: Test results of foundry sand

Colour	Black
Fineness modulus	3.05
Specific Gravity	2.46

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.

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 M20 grade mix. Concrete cubes were casted and tested after 7days and 28 days curing for compressive strength and compared with compressive strength of control cubes. 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 table 6.

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

SL. NO	Percentage of GGBS Replacement with cement	Percentage of Foundry sand Replacement with Fine Aggregate				
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	320.66	645.86	615.4	615.4
Mix ratio by weight	W/C= 0.5	1	2.0141	1.911	1.911

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**	**18.223**	**27.70**
2	0+10	23.7	27.12
3	0+20	29.96	30.07
4	**0+25**	**37.03**	**40.29**
5	0+30	19.11	24.14
6	5+0	22.66	32.15
7	5+10	23.56	28.88
8	5+20	19.85	28.44
9	**5+25**	**30.23**	**37.62**
10	5+30	14.96	25.92
11	10+0	26.81	31.70
12	10+10	27.41	34.66
13	10+20	29.78	36.59
14	**10+25**	**36.59**	**39.55**
15	10+30	20.48	23.25
16	15+0	32.59	36.14
17	15+10	30.82	36.88
18	15+20	33.19	37.48
19	**15+25**	**37.78**	**40.59**
20	15+30	23.85	27.77
21	20+0	35.70	38.81
22	20+10	35.70	39.25
23	20+20	37.04	40.59
24	**20+25**	**38.37**	**43.40**
25	20+30	25.49	31.11
26	25+0	31.12	34.51
27	25+10	29.33	34.96
28	25+20	32.44	36.29
29	**25+25**	**35.41**	**37.77**
30	25+30	24.45	29.77

Optimum Compressive strength of concrete: The results of compressive strength of concrete cubes for 7 days and 28 days are tabulated for varying percentage replacement of cement by GGBS & varying percentage 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.

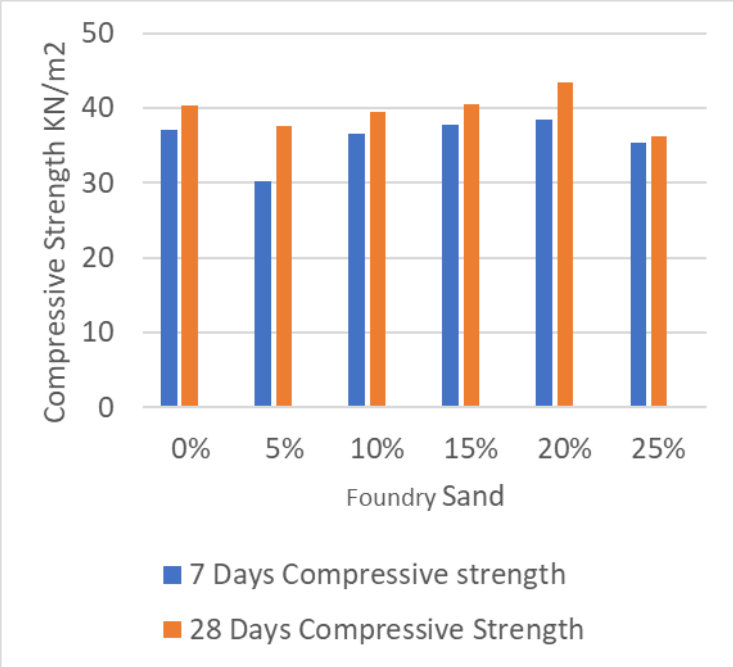

Chart -1: Graph shows the Optimum compressive strength of concrete

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 M20 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 M20 grade of concrete mix are 20% replacement of cement by GGBS and 25% replacement of fine aggregate by Foundry sand, which gives 57% more compressive strength than the results of conventional concrete and target strength of M20 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.

REFERENCES

[1] Adarsh S et.al ''Partial replacement of fine aggregate by used foundry sand in concrete'' International research journal of engineering and technology (IRJET)

eISSN:2395-0056 p-ISSN: 2395-0072 volume:04 Issue:03 | Mar-2017 pp-165-169.

[2] Aravind Singh et.al ''Effect Partial replacement of Cement by Ground granulated blast furnace slag (GGBS) and fine aggregate by marble slurry on properties of concrete'' American Journal of Indian Research eISSN:2320-0847 p-ISSN: 2320-0936 volume:06 Issue:01 | pp-28-31,2017.

[3] Dushyant R Bhimani "Used foundry sand: opportunities for development of eco-friendly low-cost concrete", journal of international Academic research and multidisciplinary (JIARM) ISSN:2320-5083 volume:01 Issue:03 | April-2013 pp-206-217.

[4] Eknath P. Salokhe, D.B. Desai et.al: Application of Foundry sand in manufacture of concrete, Journal of Mechanical and Civil engineering (IOSR-JMCE) ISSN:2278-1684 volume:04 Issue:03 | Mar-2017 pp-43-48.

[5] Girish hombal et.al "Experimental study on strength characteristics of concrete by replacement of cement with GGBS and fine aggregate by M-sand for Sustainable construction" International research journal of engineering and technology (IRJET) ISSN: 2582-4526 Volume: 02 Issue: 08 August-2016 pp-22359-22368.

[6] Samdish Arbol et.al: Effect of steel slag in concrete in Concrete. International Journal of Civil Engineering (IJCE) – eISSN-1694-2280 pISSN-1694-2396 volume:03 Issue:02|Oct-2016 pp-34-41.

[7] Santosh Kumar K et.al: Strength and Durability Studies on GGBS Concrete-SSRG. International Journal of Civil Engineering (SSRG-IJCE) – ISSN-2348-8352 volume:02 Issue:10 | Oct-2015 pp-34-41.

[8] Sumanth doodala et.al: study on partial replacement of cement by GGBS and Coarse aggregate with steel slag. International Journal of Innovative Research in Science Engineering and Technology (IJIRSET). eISSN:2319-8753, pISSN-2347-6710 Vol 6, Issue: 12 December 2017.

[9] T Suresh Babu, M Anvesh Kumar et.al: an experimental investigation on the properties of concrete containing manufactured sand & GGBS-International Journal of Applied Research eISSN:2394-5869 p-ISSN: 2394-7500 volume:02 Issue:01 | Mar-2016 pp- 362-369.

[10] Venu Malagavelli.et.al: High performance concrete with GGBS and Robo sand. International journal of Engineering science and technology (IRJET) ISSN: 0975-5462 volume: 2 Issue: 05 | Dec-2013 pp-5107-5113.

[11] M S Shetty, Concrete Technology Theory and Practice, S Chand Publication, 2013 New Delhi.

IS CODES:

- IS: 456-2000: Code of practice- plain and reinforced concrete, BIS, New Delhi-2000.
- IS:10262-2009 "Concrete Mix Proportioning – Guidelines" BIS, New Delhi-2009
- IS:516-1959 "Methods of tests for strength of concrete" BIS, New Delhi-2004
- IS: 1199-1959 "Indian Standards methods of sampling and analysis of concrete" BIS, New Delhi, India.
- IS: 383-1970 "Specification for Coarse and Fine Aggregates from Natural Sources for Concrete" BIS, New Delhi-1970.
- IS: 8112-1989 (Reaffirmed 2005): Specification for 43 Grade Ordinary Portland Cement, BIS, New Delhi-2005.
- IS: 9103-1999 (Reaffirmed 2004): "Concrete Admixtures-Specifications" BIS, New Delhi-2004.