AN EXPERIMENTAL INVESTIGATION ON REINFORCED CONCRETE CONTAINING GGBFS

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Abstract – *Use of steel is known to increase flexural strength in concrete beams. However, the literature mainly consists of studies on beams with reinforced concrete along with the cement replacing materials. The present investigation aims to study the behavior of concrete beams with steel reinforcement and also to evaluate the performance of plain concrete flexure member and reinforced concrete flexure members with Ground Granulated Blast Furnace Slag. GGBFS content used in present work are 30% and 40% as cement replacing material. The study was conducted with two water cement ratios: 0.35 and 0.40 for M 40 grade of concrete. The study was performed with three different reinforcement contents, with doubly reinforced sections containing two bars of 6mm, 8mm and10mm as the main reinforcement and two bars of 6mm, 6mm and 8mm as compression reinforcement respectively. The specimens were tested for strength in compression; flexure and splitting tensile strength at the age of 28 and 56 days. Durability and deflection test also conducted on beam specimen*

Key Words: (Size 10 & Bold) Key word1, Key word2, Key word3, etc (Minimum 5 to 8 key words)…

1. INTRODUCTION

Concrete is a combination of cement, sand, coarse aggregate and water. Its realization lies in a reality that can be designed to resist hostile environments while taking the most inspiring forms. Engineers and scientists are trying to increase their limits with the help of innovative chemical additives and several additional SCM.

1.1 SUPPLEMENTARY CEMENTATIONS MATERIALS

There are many researchers who have worked in the design of concrete (standard concrete and high strength) for better performance and strength. Inorganic materials have pozzolanic properties. These very fine grain materials are added to the concrete mix to improve concrete properties (mineral additives). They are testing and using products that incorporate limestone, fly ash, blast furnace slag and other useful materials with pozzolanic properties in the mixture. This development is one of the largest producers (of around 5 to 10%) of global emissions of greenhouse gases, as well as cost reduction, improvement of concrete properties and waste recycling. The present study aimed to evaluate the performance of plain concrete flexure member and reinforced concrete flexure members with GGBFS for M 40 grade. Beam specimens with GGBFS content equal to 30% and 40% were made. The study was conducted with two water cement ratios:0.35 and 0.40. The study was performed with three different reinforcement contents, with doubly reinforced sections containing two bars of 6mm, 8mm and10mm as the main reinforcement and two bars of 6mm, 6mm and8mm as compression reinforcement respectively.

2. LITERATURE REVIEW

Salient points from the previous studies on concrete containing Ground granulated blast furnace slag and Reinforced concrete are presented below:

Johnpaul et. al. 2019, Discussed that in readily developing countries like our Republic of India, we have a tendency to consume a lot of cement for infrastructure development. During this context, we have a tendency to now not use natural resources, questioning our future climate conditions for our country. This additionally ends up in warming.

Sanni et. al. 2018, Study the Statics serves to assess the behavior of engineering structures beneath totally different masses. The foremost common strategies of structural analysis embrace analytical methods, experimental strategies and numerical methods.

Rao et. al. 2018, Discussed the main objective is to cut back the prices of the materials used for construction, especially steel. Steel is that the material used for all kinds of reinforcements in columns, beams and slabs. The most disadvantage of this material is that it corrodes simply once it interacts with wetness and, thanks to this impact, its resistance is additionally considerably reduced and ends up in a retardant of sturdiness in buildings.

Kaviya.R et. al. 2017, Discussed that the Concrete has become an important a part of our lives, with concrete getting used at a awfully high rate. one among the most parts of hydraulic cement. Cement producing produces important CO2 emissions. Thus, researchers began to seek out alternatives to the partial replacement of cement.

3. EXPERIMENTAL PROGRAM

Concrete is a composite material which is prepared with mix of cement, fine aggregate, coarse aggregate and water. It can be widely used for any type of structure as per choice and demand and percentage constituents of concrete can be changed as per load and strength requirement by infrastructure. Concrete is economical as compared to steel structure and it has also low cost of maintenance, easy mechanism for work. Evaluate the performance of concrete containing supplementary cementations materials such as GGBS. The necessity of high-performance concrete is increasing because of demands in the construction industry. Efforts for improving the performance of concrete over the past few years suggest that cement replacement materials along with Mineral & chemical admixtures can improve the strength and durability characteristics of concrete. The challenge for civil engineering community in the near future is to realize projects in harmony with the concept of sustainable development and involves the use of high performing waste material manufactured at reason able cost.

3.1 RAW MATERIALS

Aggregate is the composite material that resists compressive stress and provides bulk to the composite material. For efficient filling, aggregate should be much smaller than the finished item, but have a wide variety of sizes. There are mainly two type of aggregate which are used for this study are given as follows:

1. Coarse Aggregate
2. Fine Aggregate

3.1.1 CEMENT

The Ordinary Portland Cement of 43 Grade conforming to IS: 8112 - 1989 was used for the present experimental study. Specific gravity of cement was 3.15.

Table -1: Properties of Cement (OPC 43 grade)

Chemical Composition	Value
CaO	62%-67%
SiO2	17% - 25%
Al2O3	3% - 8%
Fe2O3	3%-4%
MgO	0.1%-3%
SO3	1%-3%
Na2O	0%-0.5%
Gypsum (CaSO4.2H2O)	2.5%

3.1.2GROUND-GRANULATED BLAST-FURNACE SLAG

Ground-granulated blast-furnace slag is a specially processed product based on slag of high glass content with high reactivity obtained through the process of controlled granulation. Ground-granulated blast-furnace slag, although finer than OPC and it does not typically have higher water demand as compared to OPC in concrete Owing to its unique chemistry and ultra-fine particle size, It has low absorption and denser packing features (smaller particles of Ground-granulated blast-furnace slag nestling between the OPC grains).

Fig -1: Ground-granulated blast-furnace slag

3.1.3 CHEMICAL ADMIXTURE

Chemical admixtures are the ingredients in concrete other than Portland cement, water, and aggregate that are added to the mix immediately before or during mixing. Producers use admixtures primarily to reduce the cost of concrete construction; to modify the properties of hardened concrete to ensure the quality of concrete during mixing, transporting, placing, and curing and to overcome certain emergencies during concrete operations.

Super plasticizers, also known as plasticizers or high-range water reducers (HRWR), reduce water content by 12 to 30 percent. The superplasticizer which is used for the experimental performance is Kavassu Plast SP-431/ Shali plast SP-431.

3.1.4 REINFORCING STEEL BEAM DETAILS

100mm×100mm in cross-section and 500 mm long beam samples were casted. The reinforcing cages consisted of two 6mm and8mm diameter HYSD bars at the Tension side, two 6mm, 8mm and10 mm bars as hanger bars and 6mm two legged stirrups.

4. SIEVE ANALYSIS

100mm×100mm in cross-section and 500 mm long beam samples were casted. The reinforcing cages consisted of two 6mm and8mm diameter HYSD bars at the Tension side, two 6mm, 8mm and10 mm bars as hanger bars and 6mm two legged stirrups.

4.1 FINE AGGREGATE GRADING

As per IS-383:1970, Banas Sand of zone - II was recommended for concrete mix.

Table -2: Sieve Analysis of Fine Aggregate (IS 383/2386)

Sieve size	Retained (gm)			% Retained weight	Cumulatie % Retained	Cumulative % Passing	Limit as Per IS 383
	Sample 1	Sample 2	Average				
10 mm	0	0	0	0	0	100	100
4.75 mm	11.5	11.5	11.5	1.15	1.15	98.85	90-100
2.36 mm	16	18	17	1.7	2.85	97.15	75-100
1.18 mm	72	75	73.5	7.35	10.2	89.80	55-90
600 micron	522	493	507.5	50.75	60.95	39.05	35-59
300 micron	276	355	315.5	31.5	92.45	7.55	8.0-30
150 micron	90	42	66	6.6	99.5	0.5	0-10
PAN	12	5.5	8.75	0.875	267.1		
Total	1000	1000	1000	100			

Fineness Modulus = 267.10/100 = 2.67

Grading Zone = II

Test accepted / rejected under clause-Accepted as per 4.3 (Table 4) of IS: 383- 1970

Table -3: Sieve Analysis of 10 mm Aggregate (IS 383/2386)

Sieve size	Retained (gm)			% Retained weight	Cumulatie % Retained	Cumulative % Passing	Limit as Per IS 383
	Sample 1	Sample 2	Average				
12.5 mm	0	0	0	0	0	100	100
10 mm	35	46	40.5	2.01	2.01	97.99	85-100
4.75 mm	1365	1361	1363	68.15	70.16	29.84	0-20
2.36 mm	495	490	492.5	24.62	94.79	5.21	0-5
1.18 mm	105	103	104	5.2	100	0	0
600micron	0	0	0	0	100	0	0
300micron	0	0	0	0	100	0	0
150micron	0	0	0	0	100	0	0
PAN	0	0	0	0	**566.96**		

Fineness Modulus = 566.96/100 = 5.67

Table -4: Sieve Analysis of 20 mm Aggregate (IS 383/2386)

Sieve size	Retained (gm)			% Retained weight	Cumulative % Retained	Cumulative % Passing	Limit as Per IS 383
	Sample 1	Sample 2	Average				
40 mm	0	0	0	0	0	100	100
20 mm	1185	1166	1176	58.80	58.80	41.20	85-100
10 mm	734	745	740	36.97	95.74	4.23	0-20
4.75 mm	75	85	80.5	4.0125	99.75	0.25	0-5
2.36 mm	4	6	5	0.25	100	0	0
1.18 mm	0	0	0	0	100	0	0
600micron	0	0	0	0	100	0	0
300micron	0	0	0	0	100	0	0
150micron	0	0	0	0	100	0	0

5. CONTROL MIX

Control mix was designed as per IS 10262:2009 specification and recommendation which are given below:

Table 5: Control Mix Proportion for M40 (For 1 Cum. of Concrete)

S.No	Materials	Quantities in Kg/m3	
1.	Cement (OPC-43)	377	330
2.	Coarse aggregate	1136	1159
3.	Fine aggregate	886.4	904.5
4.	Water	132 litre	132 litre
5.	Super-plasticizer	2.64	2.31
6.	W/C Ratio	0.35	0.40

Following Test is Adopted for testing of concrete

1. Slump
2. Compressive Strength
3. Flexural Strength
4. Splitting Tensile Strength
5. Durability

5.1 COMPRESSIVE STRENGTH

IS Code 516:1959 use for method of tests for compressive strength of concrete. The size of specimens 150mm x 150mm x 150mm. The specimens were tested after deep curing for 7 days and 28 days.

Compressive strength = P/A (Unit = N/mm2 or MPa)

Where,

P = Load

A = Area of Specimen

5.2 FLEXURAL STRENGTH

IS Code 516:1959 use for method of tests for flexural strength of concrete the size of beam 500mm x 100mm x 100mm.The specimens were tested after deep curing for 28 and 56 days. The central point loading method was used for this testing.

Flexural Strength = 3PL/2bd2 = 3PL/2d3 (b=d, due to size of b and d are equal)

Where, P = Load,

L = Distance from Centre of Two Support,

b = Depth of Specimen,

d = Width of Specimen

5.3 SPLITTING TENSILE STRENGTH

IS Code 5816:1999 use for method of test splitting tensile strength of concrete. The size of 200mm(length) x 100mm(diameter). The specimens were tested after deep curing for 28 days.

Splitting Tensile Strength = 2P/ ld (Unit = N/mm2 or MPa)

Where

P= Load

l= Length of Cylinder

d = Diameter of Cylinder

5.4 DURABILITY

The samples immersed in 5% concentration of H_2SO_4 in place of water curing then analysis the loss in strength or strength reduction. In present work reinforced beam sample is immersed in acid solution.

6. TEST RESULTS

6.1 SLUMP

The Slump test results of control mix and concrete prepared with 30% and 40% GGBFS as a partial replacement of Cement with 0.35 and 0.4 water cement ratio are presented graph.

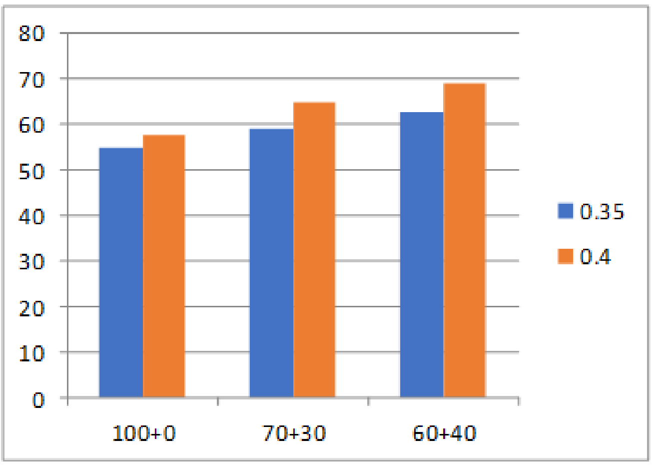

Fig-2: Slumps of Concrete Mixes

6.2 COMPRESSIVE STRENGTH

The compressive strength test results of concrete cube prepared with 30% and 40% GGBFS as a partial replacement of cement (average of three) with two different w/c ratios at the ages of 28 days and 56 days are presented in graph.

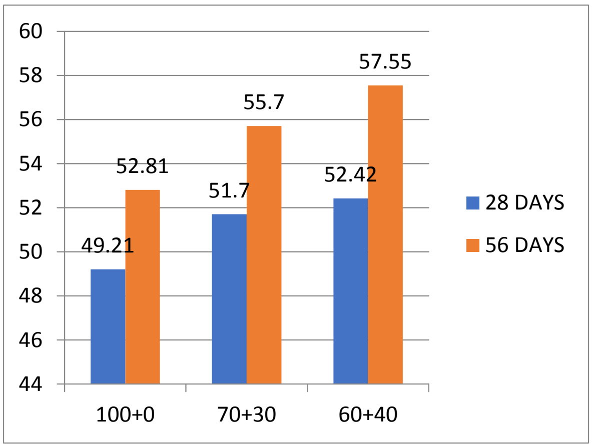

Fig-3 Compressive Strength of Plain Concrete Mixes with 0.35 W/C Ratio

The compressive strength test results of concrete cube prepared with 30% and 40% GGBFS as a partial replacement of cement with 0.35 w/c ratios at the ages of 28 days and 56 days are presented in figure 4.2. And it is observed that 40% content of GGBFS increases the compressive strength at the age of 28 and 56 days respectively. With 30% and 40% GGBFS content in the mix and w/c ratio 0.35, the compressive strength increases around 3% to 5% at the age of 28 days and increases 4% to 7% at the age of 56 days compared to Control mix.

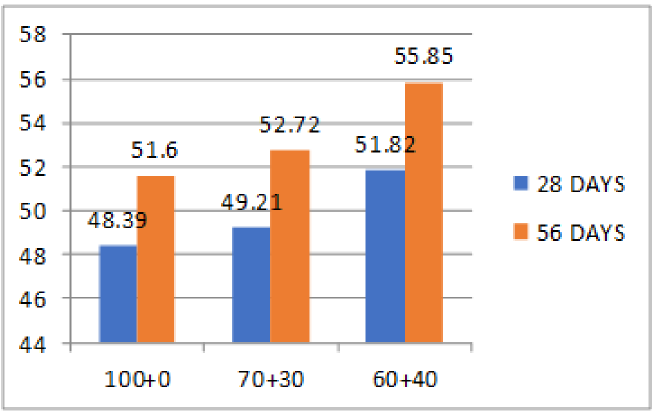

Fig-4 Compressive Strength of Plain Concrete Mixes with 0.4 W/C Ratio

6.3 FLEXURAL STRENGTH

The flexural strength test results of concrete cube prepared with 30% and 40% GGBFS as a partial replacement of cement (average of three) with two different w/c ratios at the ages of 28 days and 56 days are presented in graph.

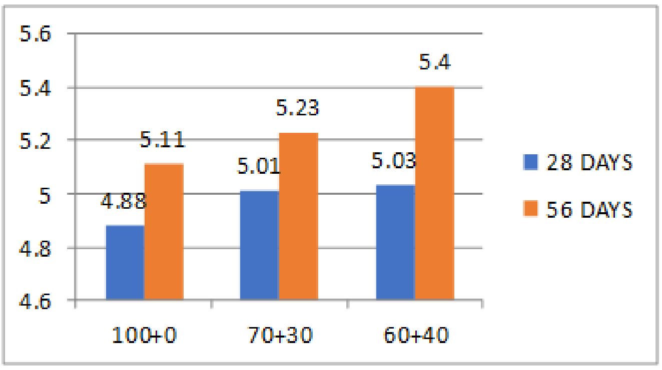

Fig-5: Flexural Strength of Plain Concrete Mixes with 0.35 W/C Ratio

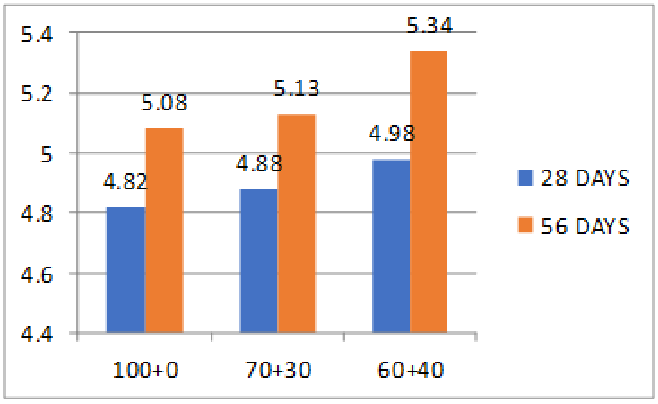

Fig-6: Flexural Strength of Plain Concrete Mixes with 0.4 W/C Ratio

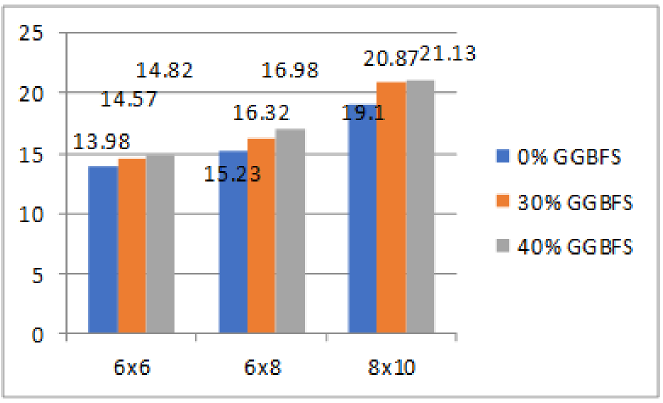

Fig -5 Comparison of Flexural Strength of Reinforced Concrete with GGBFS at the age of 28 days and w/c ratio 0.35

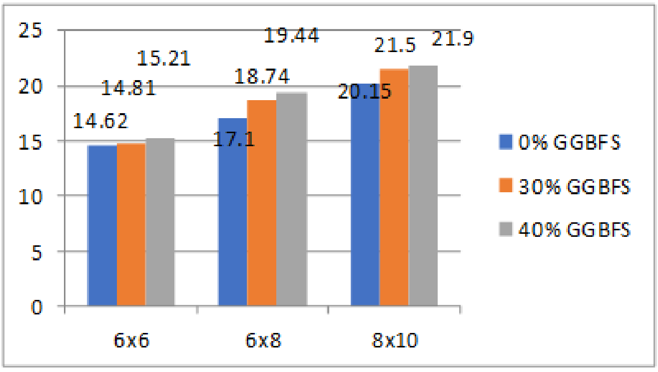

Fig -6 Comparison of Flexural Strength of Reinforced Concrete with GGBFS at the age of 56 days and w/c ratio 0.35

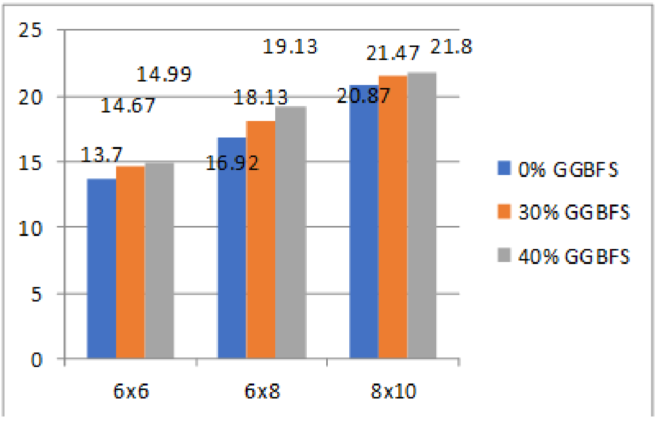

Fig-7 Comparison of Flexural Strength of Reinforced Concrete with GGBFS at the age of 56 days and w/c ratio 0.40

7. COMPARISON IN DEFLECTION OF REINFORCED BEAM WITH 0%, 30% AND 40% REPLACEMENT OF CEMENT WITH GGBFS

Comparison in Deflection of reinforced beam with 0%, 30% and 40% replacement of Cement with GGBFS at the age of 56 days are represented in graph.

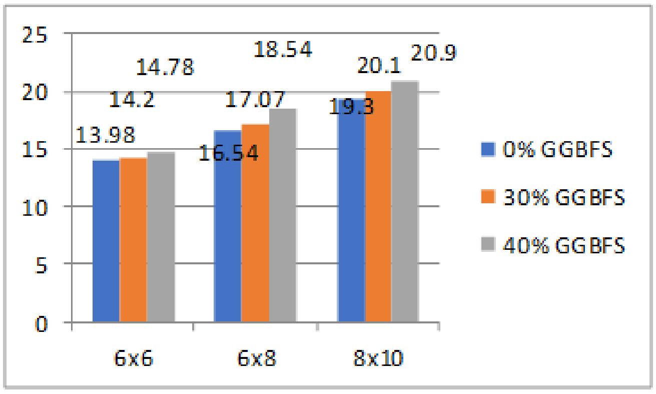

Fig -8 Flexural Strength of Reinforced Concrete with GGBFS and 0.35 w/c ratio at the age of 56 days under Acid Curing

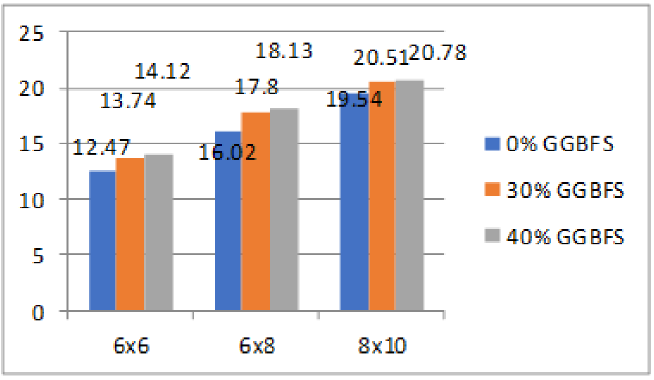

Fig -8 Flexural Strength of Reinforced Concrete with GGBFS and 0.4 w/c ratio at the age of 56 days under Acid Curing

Mix prepared with 0% GGBFS, the variation or loss in strength obtained in the range of 5% to 8% comparison to the results obtained by water curing at the age of 56 days.

Mix prepared with 30% GGBFS, the variation or loss in strength obtained in the range of 2% to 6% comparison to the results obtained by water curing at the age of 56 days.

Mix prepared with 40% GGBFS, the variation or loss in strength obtained in the range of 4% to 6% comparison to the results obtained by water curing at the age of 56 days.

8. COMPARISON OF TEST RESULTS WITH DIFFERENT INVESTIGATORS

A comparison of Deflection test results of the present study with those reported by other investigators (at the age of 28 and 56 days) is shown in Table.

Table 6 Comparison with Different Investigators

INVESTIGATORS	DESCRIPTION	DEFLECTION (IN MM)	
P Subhatra & Jaylakshmi	Hanger Bar of 2#10 Tension Bar of 2#12 Grade of Concrete - 25	HYSD BARS	4.98 mm
		C- BAR	7.20 mm
Present Work	Hanger Bar of 2#8 Tension Bar of 2#10 Grade of Concrete - 40	MILD STEEL BARS	8.1 – 9 mm

Table 7 Comparison with Different Investigators

Investigators	Description	GGBFS CONTENT	Deflection (in mm)	
		(%)	28	56
Dr. S.P Sangeetha	Hanger Bar of 2#10 Tension Bar of 3#12 Grade of Concrete M-35	0%	8.5-9 mm	7.5-8 mm
		40%	8.1-9 mm	7.5-8.1mm
Present Work	Hanger Bar of 2#8 Tension Bar of 2#10 Grade of Concrete -40	0%	7.8-8.2 mm	8.1-8.5 mm
		40%	8.1-8.5	8.9-9 mm

9. CONCLUSIONS

1. Partially replacing Cement with GGBFS 30% to 40% the slump increases significantly.

2. Partially replacing Cement with GGBFS, the consumption of Cement from cement production reduces significantly also enhanced the strength (Compression, flexure and Splitting tensile) comparison to control mix at the ages of 28 and 56 days respectively.

3. Flexural strength of plain concrete at the age of 56 days

It was observed that the flexural strength of plain concrete beams increased in the range of 2% to 6% compared to Control mix, with partially replacement of Cement by GGBFS in the range of 30% to 40% respectively with 0.35 water cement ratio.

4. Flexural strength of Reinforced concrete at the age of 28 days

It was observed that the values of flexural strength for a beam which is prepared with partially replacement of Cement by GGBFS in the range of 30% to 40% and Hanger Bar and Tension Bar taken 2#6 and 2#6 respectively and w/c ratio 0.35. The Flexural strength of reinforced beam increased in the range of 1% to 6%

5. It was observed that the values of flexural strength for a beam which is prepared with partially replacement of Cement by GGBFS in the range of 30% to 40% and Hanger Bar and Tension Bar taken 2#8 and 2#10 respectively and w/c ratio 0.35. The Flexural strength of reinforced beam increased in the range of 4% to 10.6%

6. Flexural strength of Reinforced concrete beam with Acid curing (56 Days)

It was observed that the values of flexural strength for a beam which is prepared with partially replacement of Cement by GGBFS in the range of 30% to 40% and Hanger Bar and Tension Bar taken with different sets of diameter bars and acid curing for 56 days, w/c ratio 0.35 and 0.4. The Flexural strength of reinforced beam decreased in the range of 3% to 6% and 4% to 8% respectively compared to reinforced beam of control mix.

7. Deflection in Reinforced concrete beam

A comparison of Deflection test results of the present study with those reported by other investigators at the age of 28 and 56 days, lie in the almost same range of the results given by other investigators.

REFERENCES

[1] V. Johnpaul, N. Balasundharam, S. Sanothini. Pragadheesh , Kameshwaran J, Satheesh kumar M, M. Balajimanikandan, " An Experimental Study on Flexural Behaviour of Nano Ggbfs Concrete", International Journal of Recent Technology and Engineering (IJRTE), Volume-7, Issue-6S5,PP-1744-1747, April 2019.

[2] Dr. Shankar H. Sanni and Keshavraj. Girinivas, "Analytical Investigations on Reinforced Concrete Beams", International Research Journal of Engineering and Technology (IRJET), Volume-05, Issue-12, PP-1509-1513, Dec 2018.

[3] P. Rama Mohan Rao and S. Karthik," Investigation on Flexural Behaviour of Beam with Bamboo as Main Rebars",International Journal of Recent Technology and Engineering (IJRTE), ISSN: 2277-3878, Volume-7 Issue-4S2, PP- 173-177, December 2018.

[4] Rathan Raj R, Ganesh Prabhu G and Perumal Pillai E B, " Flexural Behavior of Concrete Beam with GGBS and Fly Ash as Supplementary Cementitious Material", International Journal of Applied Engineering Research, Vol-10, No-47, PP-32310-32315, 2015.

[5] B.Kaviya.R, Arjun, Rajkumar. P, Ramakrishnan. S and Subash. S, "Study on Partial Replacement Of Cement By Ground Granulated Blast Furnace Slag (GGBS)", International Journal of Pure and Applied Mathematics, Vol-116, No-13, PP-411-416, 2017.

[6] Divyadevi Sundaravadivel and Dr. R. Mohana, "Recent Studies of Sugarcane Bagasse Ash in Concrete and Mortar- A Review", International Journal of Engineering Research & Technology (IJERT), Vol. 7, Issue 04, PP-306-312, April 2018.

[7] J.Vengadesh Marshall Raman and V.Murali Krishnan, "Partial Replacement of Cement with GGBS in Self Compacting Concrete for Sustainable Construction", SSRG International Journal of Civil Engineering (SSRG – IJCE), Volume 4, Issue 3, PP-22-25, March 2017.

[8] Sonali K. Gadpalliwar, R. S. Deotale and Abhijeet R. Narde, "To Study the Partial Replacement of Cement by GGBS & RHA and Natural Sand by Quarry Sand In Concrete", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume 11, Issue 2, Ver. II, PP-69-77, Mar- Apr. 2014.

[9] Mr. P. Brightson, Mr. M. Prem Anand and Dr. M. S. Ravikumar, "Flexural Behavior of Beams Incorporating GGBS as Partial Replacement of Fine Aggregate in Concrete", Advanced Materials Research Vols-984-985, PP-698-706, 2014.

[10] Mrs. S. P. Sangeetha and Dr. P. S. Joanna, "Flexural Behaviour of Reinforced Concrete Beams With GGBS", International Journal of Civil Engineering and Technology (IJCIET),Volume-5, Issue-3, PP-124-131, March 2014.

[11] Dattatreya J K, Rajamane NP, Sabitha D, Ambily P S and Nataraja MC, "Flexural behavior of reinforced Geo polymer concrete beams", International Journal Of Civil And Structural Engineering, Volume-2, No-1, PP-138-159, 2011.

[12] Chithra P, Naveen Kumar A B, Vivekananthan V, "Experimental Study on Structural behaviour of reinforced concrete beams containing Sisal fiber and GGBS", International Journal of Multidisciplinary Research Transactions", Volume-1, Issue-3, PP-22-30, May 2019.

[13] Dr. S. P. Sangeetha, "Strength and Flexural Behaviour Of Reinforced Concrete With Ground Granulated Blast Furnace Slag", International Journal of Pure and Applied Mathematics, Volume-118, No-5, PP-867-879, 2018.

[14] Dr. B. Vidivelli, M. Gopinath and T. Subbulakshmi, "Study on flexural behaviour of reinforce concrete beam with GGBS and steel fibre", International Journal of Scientific & Engineering Research, Volume-7, Issue-6, PP-719-730, June-2016.