RESEARCHERID
THOMSON REUTERS

[NC-Rase 18]
DOI: 10.5281/zenodo.1494065

ISSN 2348 – 8034
Impact Factor- 5.070

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

DURABILITY STUDY OF HIGH STRENGTH CONCRETE USING GROUND GRANULATED BLAST FURNACE SLAG

S. D. Mankar [*1], C.S.Bidwaik[2] & S.H. Jadhv[3]

[*1,2,3] Assistance Professor, Civil Engineering Department, MGICOET, Shegaon, India

ABSTRACT

The present study is to use the waste product from steel industry which is helpful in cement production and also helps to reduce the carbon emission. Ground Granulated Blast Furnace Slag (GGBFS) is used as a mineral additive in concrete and substitutes for cement, it behaves as a binder material along with cement. The optimum dosage of GGBFS as cementitious material is characterized by high compressive strength, low heat of hydration, resistance to chemical attack, better workability, good durability and cost-effective. This paper presents a laboratory investigation on optimum level of ground granulated blast-furnace slag on compressive strength of concrete. 12 concrete mixes were cast with water to cementitious material (w/cm) ratio 0.30 and 0.28 each; using GGBFS as partial replacement of cement from 0% to 50% at an interval of 10%. The specimens were cured for 28 days in potable water to examine compressive strength of concrete. The test results showed that the compressive strength of concrete samples increases as the amount of GGBFS increases, upto optimum dosages of GGBFS. The optimum dosage of GGBFS is found at 30% and 20% replacement of cement with GGBFS.

Keywords*- High Strength Concrete, Ground Granulated Blast Furnace Slag, Compressive Strength*.

I. INTRODUCTION

Concrete is the most widely used construction material due to its significant compressive strength and low cost. The concrete mainly divided into three types: ordinary concrete, standard concrete and high strength concrete having strength 60 MPa and above [1]. Now a days High Strength Concrete (HSC) is used to reduce cross-section and there by self weight of the building. The other benefit of using HSC is that ultimate deformation decreases with the increasing strength. The requirement of high cement content in HSC is being produced using supplementary cementitious materials like fly ash, Ground granulated blast furnace slag, silica fume, metakaolin and rice husk-ash and make concrete durable [2-4]. In the region, of rapidly growing steel industries, there is a big challange of disposal of waste material, produced during manufacturing of steel called ground granulated blast furnace slag (GGBFS). A study has been carried out to observe the effect of GGBFS as a partial replacement to cement. It acts as a pozzolan which results in denser and impermeable concrete structure as the pore space filled with C-S-H rather than in Portland cement [5-6]. The presence of GGBFS in the concrete improves the workability and the mobility of the concrete mix with cohesiveness. This is due to surface characteristics of the GGBFS which are smooth and absorb little water during mixing. Concrete containing GGBFS have long term strength development due to very slow initial hydration of GGBFS. The progressive release of alkalis by the GGBFS, together with the formation of calcium hydroxide by Portland cement, results in continuing reaction of GGBFS over a long period. The GGBFS enhances durability of concrete due to its dense micro-structure [7].

II. METHOD & MATERIAL

2.1 Experimental Program

Experimental programme is executed to determine the optimum dosage of GGBFS for w/cm ratio 0.30 and 0.28 using the Department of Environment (DOE) method. To reach target compressive strength the concrete cubes of 150 x 150 x 150 mm size were cast using GGBFS as 10%, 20%, 30%, 40% and 50% replacement with cement at water to cementations material ratio (w/cm) 0.30 and 0.28. The dosage of superplasticizer varies as 1.5% to 1.8% for respective replacement of GGBFS. In all 12 mixes and 36 concrete cubes were cast.

2.2 Materials used

Ordinary Portland Cement (OPC) 53 grade conforming to IS: [12269-1987] has been used. The GGBFS produced by JWS Cement, Pune are used. The GGBFS consists essentially of silicates and alumino silicates of calcium. It confirms to Indian standard code, IS [12089-1987].The physical and chemical properties of cement and GGBFS are mentioned in Table.1

Table 1. Physical and Chemical properties of OPC and GGBFS

Sr. No.	Properties	Cement	GGBFS
1	Fineness (m^2/kg)	380.00	424
2	Specific gravity	3.13	2.96
3	C_aO	63.76	37.34
4	SiO_2	20.69	37.73
5	Al_2O_3	4.72	14.42
6	Fe_2O_3	3.06	1.11
7	M_gO	2.08	8.71
8	SO_3	2.92	--
9	K_2O	0.61	--
10	Na_2O	0.26	--

Crushed stone metals locally available with a size of 12.5 mm and below from a local conforming to the requirements of IS: [383-1970] were used. Locally available Godavari river sand passing through 4.75 mm IS sieve conforming to grading zone-II of IS: [383-1970] was used. The fineness modulus for coarse and fine aggregates are 6.31 and 3.49, also the specific gravity of coarse and fine aggregates are 2.83 and 2.49 respectively. Potable water was used for mixing and curing of concrete specimens and Conplast SP 430 of FORSOC chemicals (India) Pvt. Ltd, Bangalore, confirming to IS [9103-1999] was used as superplasticing admixture based on sulphonated napththalene polymers having specific gravity as 1.22 - 1.225 at 30^0C. Mix proportions are presented in Table 2 and 3.

Table 2. Mix Proportions for w/cm ratio 0.30

Mix Proportion	GGBFS %					
	0%	10%	20%	30%	40%	50%
Cement (Kg/m^3)	569.00	512.00	455.20	398.30	341.40	284.50
F.A.(Kg/m^3)	728.00	728.00	728.00	728.00	728.00	728.00
C.A.(Kg/m^3)	1028.00	1028.00	1028.00	1028.00	1028.00	1028.00
Water (Kg/m^3)	171.00	164.17	163.0.	162.47	161.90	161.33
GGBFS (Kg/m^3)	0.00	56.90	113.80	170.70	227.60	284.50
HRWR(Kg/m^3)	5.69	6.83	7.97	8.54	9.10	9.67
Slump in mm	65.00	70.00	75.00	80.00	85.00	90.00

[NC-Rase 18] ISSN 2348 – 8034
DOI: 10.5281/zenodo.1494065 Impact Factor- 5.070

Table 3. Mix Proportions for w/cm ratio 0.28

Mix Proportion	GGBFS %					
	0%	10%	20%	30%	40%	50%
Cement (Kg/m^3)	589.28	530.35	471.42	412.50	353.57	294.64
F.A.(Kg/m^3)	633.00	633.00	633.00	633.00	633.00	633.00
C.A.(Kg/m^3)	987.00	987.00	987.00	987.00	987.00	987.00
Water (Kg/m^3)	165.00	154.98	154.39	154.10	153.80	153.51
GGBFS (Kg/m^3)	0.00	58.93	117.86	176.78	235.71	294.64
HRWR(Kg/m^3)	8.80	10.02	10.61	10.90	11.20	11.49
Slump in mm	50.00	55.00	60.00	65.00	75.00	80.00

III. TESTING PROCEDURE

The experimental investigation consist of making concrete cubes by using above mentioned mix proportions to determine the compressive strength of the concrete. The required materials were weighed and machine mixed. Cube specimen of sized 150mm x 150mm x150mm were casted. Three cubes for each mix proportions were casted. The specimens were de-molded after 24 hours of casting and cured in a tank for 28 days. Compression testing was done using compression testing machine as per IS [516-1959].

IV. RESULTS AND DISCUSSION

4.1 Optimum Strength

The replacement percentage of cement with GGBFS is shown on X-axis and compressive strength on Y-axis in the given Figure 1 and Figure 2. Given results represents that, the compressive strength increases as the replacement percentage increases upto optimum point after that the compressive strength decreases as shown in Figure 1 and Figure 2. The highest strength gained is found to be 72.64 MPa for w/cm ratio 0.30 at 30% replacement, while for w/cm ratio 0.28 is found to be 81.30 MPa at 20% of GGBFS. From Figures, it is observed that the peak value decreases with increase in percentage of GGBFS; this indicates that additional GGBFS remain inert with concrete and behaves as fine aggregates. Also, after optimum limit, GGBFS can be used as filler rather than as a binder in concrete.

ISSN 2348 – 8034
Impact Factor- 5.070

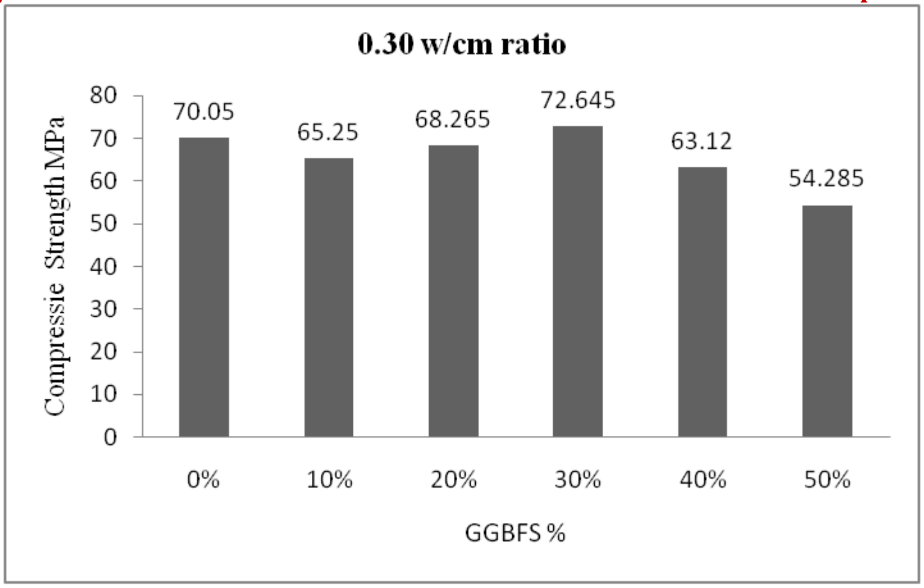

Figure 1.Optimum compressive strength at 0.30 w/cm ratio.

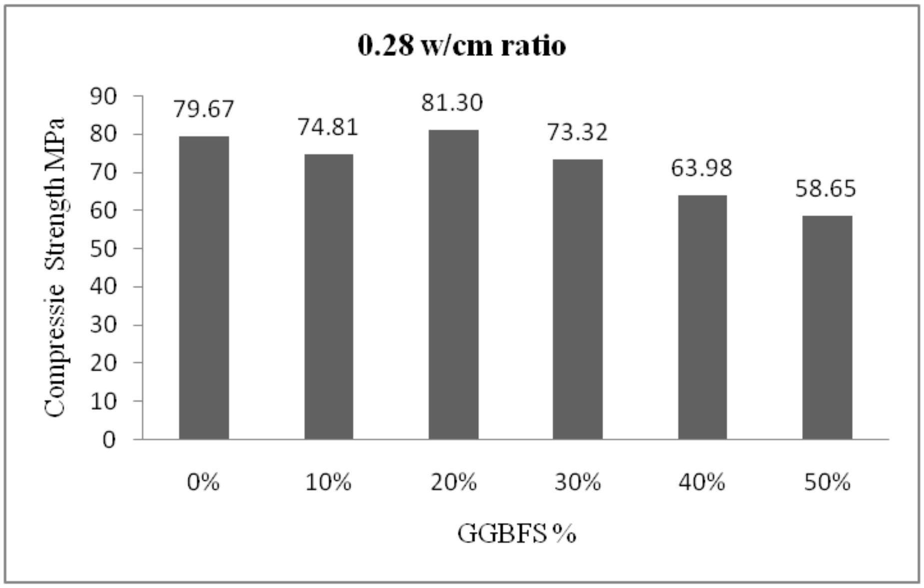

Figure 2.Optimum compressive strength at 0.28 w/cm ratio.

V. CONCLUSIONS

1. Highest compressive strength of concrete for 28 days water curing are found to be 72.65 MPa and 81.30 MPa for w/cm ratio of 0.30 and 0.28 at 30% and 20% replacement of cement with GGBFS.
2. The results of compressive strength of concrete with w/cm ratio of 0.30, 0.28 for optimum dosage of GGBFS 30%, 20% replacement indicate that high strength concrete can be produced using GGBFS

[NC-Rase 18] ISSN 2348 – 8034
DOI: 10.5281/zenodo.1494065 Impact Factor- 5.070

REFERENCES

1. *S. Purushothaman, G. Harri and S. Lokesh, "Cost Deduction Analysis on High Strength Concrete", Journal of Civil Engineering and Environmental Technology, ISSN: 2349-879X, Volume 2, Number 7, April-June 2015, pp. 630-634.*
2 *A.Oner, S Akyur, "Experimental study on optimal usage on GGBFS for compressive strength of concrete", Cement and concrete composites, 29, Received 24 March 2006, Accepted 11 January 2007, pp. 505-514*
3 *Susanto Tang, Tze Yang Darren Lim and Bahador Sabet Divsholi, S.Q, "Durability and mechanical properties of high strength concrete incorporating ultrafine ground granulated blast furnace slag", Construction and Building materials Vol. 40, 2000, pp.875-881*
4 *Vasu Krishna, Gajanan M Sabnis, "Utilization of Waste Products and By- Productsin Concrete: The Key to a Sustainable Construction", International Conference on Civil and Architecture Engineering, (ICCAE'2013) May 6-7, 2013.*
5 *Reshma Rughooputh, Jaylina Rana, "Partial Replacement of Cement by Ground Granulated Blast furnace Slag In Concrete", Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS), Vol. 5(5), pp. 340-343*
6 *Chan WWJ, Wu CML, "Durability of concrete with high cement replacement." Cement Concrete Res 2000, pp. 865–879.*
7 *Ferraris CH, Obla KH, Hill R. "The influence of mineral admixtures on the rheology of cement paste and concrete", Cement Concrete Res2001 pp. 245–55*
8 *Shetty M.S. C and A.K. Jain, "Concrete Technology." ,Rewised edition, S. Chand Publication,.*
9 *Neville, A. M., "Concrete Technology", Fourth edition, Pearson Education, New Delhi.*
10 *Krishna Raju "Design of Concrete mixes.", Fifth edition, CBS Publishers and Distributors*
11 *British Department of the environment method, "Design of normal concrete mixes", Second edition, 1988.*
12 *BIS: 12269-1987 (reaffirmed 1999) "Specification for 53 grade Ordinary Portland Cement", New Delhi Michigan*
13 *BIS 12089-1987 (reaffirmed 1999) "Specification for Granulated Slag for the manufacture of Portland Slag Cement ", New Delhi .*