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"Experimental Investigation On Optimum Strength Of High Strength Concrete Using Ground Granulated Blast Furnace Slag"

Savita D.Mankar[1]
mankarsa11@gmail.com

Anuradha P. Modak[2]
anuradhamodak0@gmail.com

Ruchira S.Ingole[3]
ruchiraingole45@gmail.com

Vijaya D. Gayki[4]
vijayagayki@gmail.com

[1,2,3,4-] Assistant Professor, Department of Civil Engineering
Mauli Group of Institution's, College of Engineering and Technology, Shegaon, India

***Abstract*—** The present study is to use the ravage 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 0.32, 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 four weeks in potable water to study compressive strength of concrete. The test results revealed that the compressive strength of concrete samples increases as the amount of GGBFS increases, upto optimum percentage of GGBFS. The optimum dosage of GGBFS is found at 40%, 30% and 20% replacement of cement for w/cm ratio 0.32, 0.30 and 0.28.

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

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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].

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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. METHODS AND MATERIALS

A. Experimental Program

Experimental programme is executed to determine the optimum dosage of GGBFS for w/cm ratio 0.32, 0.30 and 0.28 using the Department of Environment (DOE) method. To achieve 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) 0.32, 0.30 and 0.28. The dosage of superplasticizer varies as 1.2% to 1.8% for respective replacement of GGBFS. In all 18 mixes and 54 concrete cubes were cast.

B. 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	2.92	--
9	K_2O	0.61	--
10	Na_2O	0.26	--

Crushed stone metals locally available with a size of

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 300C. Mix proportions are presented in Table 2, 3 and 4.

Table 2. Mix Proportions for w/cm ratio 0.32

Mix Proportion	GGBFS %					
	0%	10%	20%	30%	40%	50%
Cement (Kg/m^3)	550.00	495.00	440.00	385.00	330.00	275.00
F.A. (Kg/m^3)	808.00	808.00	808.00	808.00	808.00	808.00
C.A. (Kg/m^3)	550.00	1045.00	1045.00	1045.00	1045.00	1045.00
Water (Kg/m^3)	176.00	171.05	170.50	169.95	169.40	168.85
GGBFS (Kg/m^3)	0.00	38.00	93.00	148.00	203.00	258.00
HRWR (Kg/m^3)	4.40	4.95	5.50	6.05	6.60	7.15
Slump (mm)	90.00	95.00	95.00	100.00	105.00	110.00

Table 3. **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

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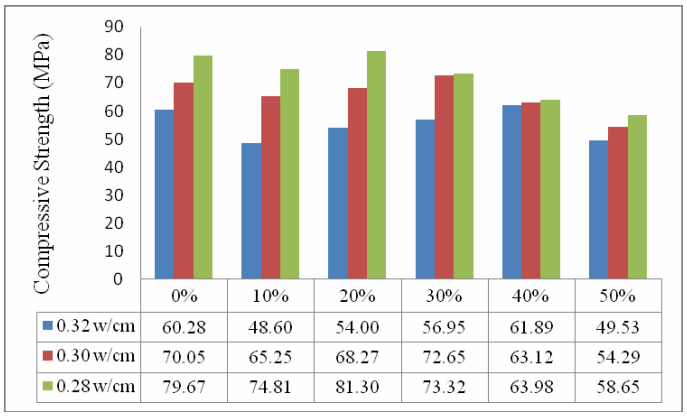
F.A. (Kg/m^3)	728.00	728.00	728.00	728.00	728.00	728.00
C.A. (Kg/m^3)	1028.00	1028.00	1028.00	1028.00	1028.00	1028.00
Water (Kg/m^3)	171.00	164.17	163.0.	162.47	161.90	161.33
GGBFS (Kg/m^3)	0.00	56.90	113.80	170.70	227.60	284.50
HRWR (Kg/m^3)	5.69	6.83	7.97	8.54	9.10	9.67
Slump (mm)	65.00	70.00	75.00	80.00	85.00	90.00

Table 4. **Mix Proportions for w/cm ratio 0.28**

Mix Proportion	GGBFS %					
	0%	10%	20%	30%	40%	50%
Cement (Kg/m3)	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 (mm)	50.00	55.00	60.00	65.00	75.00	80.00



III. TESTING PROCEDURE

The experimental programme include preparation of concrete cubes by using proportions given in above table 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 prepared. The specimens were de-molded after 24 hours of casting and cured in a water for four weeks. Compression testing was done using compression testing machine as per IS [516-1959].

IV. RESULTS AND DISCUSSION

A. 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. The highest strength obtained is found to be 61.89MPa, 72.64 MPa and 81.30 MPa for w/cm ratio 0.32, 0.30 and 28 at replacement percentage of GGBFS as 40%, 30% and 20% with cement. From Figures, it is observed that the crest value decreases with increase in percentage of GGBFS; this indicates that additional GGBFS remain inactive with concrete and behaves as fine aggregates which is used as filler rather than as a binder in concrete.

V. CONCLUSIONS

1. Highest compressive strength of concrete for four weeks ofwater curing are found to be 61.89MPa, 72.65 MPa and 81.30 MPa for w/cm ratio of 0.32, 0.30 and 0.28 at 40%, 30% and 20% replacement of cement with GGBFS.

2. The results of compressive strength of concrete with w/cm ratio of 0.32, 0.30, 0.28 for optimum dosage of GGBFS40%, 30%, 20% replacement indicate that high strength concrete can be produced using GGBFS.

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