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An Experimental Study on Optimum Dosage of Ground Granulated Blast Furnace Slag for High Strength Concrete

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Abstract— **The present investigation is to use the waste product from steel industry which is helpful in cement production if it is ground at a fineness of cement which also helps to reduce the carbon emission. Ground Granulated Blast Furnace Slag (GGBFS) is used as a mineral additive for concrete production 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.18 concrete mix sample were cast with water to cementitious material (w/cm) ratio 0.32 and 0.30 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. The compressive strength of concrete is examined.The test results revealed that the compressive strength of concrete mixtures containing GGBFS increases as the amount of GGBFSincrease, upto certain limit. The optimum dosage of GGBFS is found at. This can be explained by the presence of unreacted GGBFS, behaves as a filler material in the paste and not as a binder.**

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 (the concrete having strength up to 20MPa), standard concrete (the concrete having strength 25MPa and above up to 55MPa) and high strength concrete (the concrete having strength 60MPa and above up to 80MPa [1].Now a days High Strength Concrete (HSC) is used toreducecross-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 usingsupplementary cementitious materials like fly ash, Ground granulated blast furnace slag, silica fume, metakaolin and rice husk-ash and make concrete durable [2-4].

In Marathwada region, due to 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 GGBS in the concrete improves theworkability and the mobility of the concretemix with cohesiveness. This is due to surface characteristics ofthe GGBS which are smooth and absorb little water duringmixing.Concrete containing GGBS have long term strengthdevelopment due to very slow initial hydration of GGBS. The progressiverelease of alkalis by the GGBS, together with the formation ofcalcium hydroxide by Portland cement, results in continuingreactionof GGBS over a long period. [7].

II. EXPERIMENTAL PROGRAMME

High strength concrete is designed with help of the guidelines given by the British Department of Environment (DOE) method for compressive strength nearly equal to 60 MPa and 70 MPaby using GGBFS as replacement to cement. To achieve target compressive strength the concrete cubes of 150 x 150 x 150 mm size were cast for concrete mix proportion to replace 10%, to50% at an interval of 10% cement with GGBFS at water to cementations material ratio (w/cm) 0.32 and 0.30.The dosage of superplasticizer varies as 0.7% to 1.9% for respective replacement of GGBFS. In all 36 concrete cubes were cured upto 28 days andtested for compressive Strength.

2.1 Materials used

Ordinary Portland Cement (OPC) 53 grade conforming to IS: [12269-1987] has been used.The GGBFS produced

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by JWS Cement, Pune is used. The GGBFSconsists 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 inTable.1

Table 1. Physical and chemical properties of Cement and GGBFS

Item	Fineness (m^2/kg)	Specific gravity	LOI	C_aO	SiO_2	Al_2SO_3	Fe_2O_3	M_gO	SO_3	K_2O	Na_2O
OPC	380	3.13	0.87	63.76	20.69	4.72	3.06	2.08	2.92	0.61	0.26
GGBFS	426	2.97	1.41	37.34	37.73	14.42	1.11	8.71	....	....	....

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, alsothe 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 sulphonatednapththalene polymers having specific gravity as 1.22-1.225 at 300C. However in higher grades, namely, M60 and beyond, the dosage of superplasticizer wasadjusted based on trial to get the desired workability. Mix proportions for HSC are shown in Table 2 and Table 3 for w/cm ratio 0.32 and 0.30 respectivel

Table 2. Mix Proportionsfor w/cm ratio 0.32

Mix proportion	GGBFS %					
	0%	**10%**	**20%**	**30%**	**40%**	**50%**
Cement (kg/m^3)	533.00	479.70	426.40	373.10	319.80	266.50
F.A. (kg/m^3)	808.00	808.00	808.00	808.00	808.00	808.00
C.A. (kg/m^3)	1045.00	1045.00	1045.00	1045.00	1045.00	1045.00
Water (kg/m^3)	176.00	170.68	169.49	167.39	166.85	165.09
GGBFS (kg/m^3)	0.00	89.30	142.60	195.90	249.20	302.50
HRWR (kg/m^3)	4.11	4.99	5.87	6.45	6.40	7.46

Table 3. Mix Proportionsfor w/cm ratio 0.30

Mix proportion	GGBFS %					
	0%	**10%**	**20%**	**30%**	**40%**	**50%**
Cement (kg/m^3)	569.00	512.10	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	165.14	164.07	163.01	161.33	160.19
GGBFS (kg/m^3)	0.00	56.90	113.80	170.70	227.60	284.50
HRWR (kg/m^3)	4.80	5.86	6.93	8.00	9.67	10.81

III.TESTING PROCEDURE

The experimental investigation consisted 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

In the Figures 1 and Figure 2 it,thereplacement percentage of cement with GGBFSis shown on X-axis and compressive strengthon Y-axis. Itis observed that for 0% to 50% replacement of cement the strength increases as the replacement percentage increases upto optimum point after that the compressive strength decreases as shown in Figs 1 and 2. The highest strength gained for w/cm ratio 0.32 is found at 40% replacement, while for w/cm ratio 0.30 is found at 30%.From results, 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 as a binder in concrete.

Table 4.Average Compressive Strength at 28 Days

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w/cm Ratio	GGBFS replacement					
	0%	10%	20%	30%	40%	50%
0.32	60.28	48.60	54.00	56.95	61.89	49.53
0.30	70.05	65.25	68.265	72.645	63.12	54.285

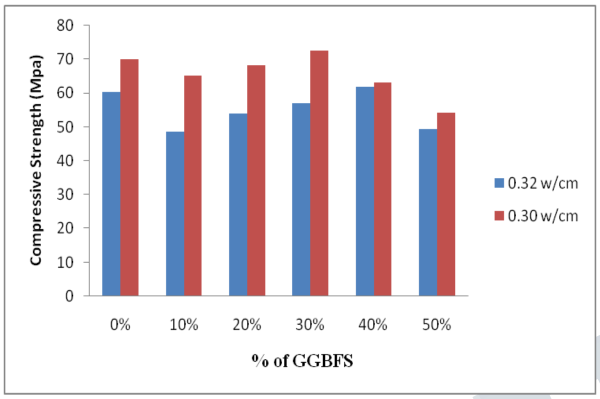

Figure 1.Optimum compressive strength at 0.32 and 0.30 w/cm ratio.

V. CONCLUSIONS

1. In high strength concrete as water/cement ratio adopted is low, superplasticizers are necessary to maintain required workability. As the percentage of mineral admixtures is increased in the mix, the percentage of super plasticizer should also be increased, for mixing and for obtaining the desired strength.
2. It is observed from the 28 days results, the maximum average strength gain at w/cm ratio0.32, 0.30, found at 40%, 30% foroptimumreplacement percentage of GGBFS.

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