Properties of Fresh and Hardened SCC Made with Ground Granulated Blast Furnace Slag and Metakaolin

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***Abstract*: The paper aims to focus on the possibilities of using industrial by products such as GGBFS and MK. The utilization of pozzolans is well accepted because of several improvement possible in the concrete composites. The present study reports the results of experimental study conducted to evaluate compressive strength of concrete, by partial replacement of cement by various percentages of ground granulated blast furnace slag (GGBS) and metakaolin (MK) (5+5%, 10+10%,15+15% and 20+20%). The compressive strength test are done onconstant W/B ratio 0.45. The efforts are made towards understanding efficiency of pozzolans in concrete considering the percentage of replacement and combinations of pozzolans. The pozzolans replacement as cementitious material is characterised by high compressive strength.**

***Keywords*: Ground granulated blast furnace slag, Metakaolin, superplasticizer, self-compacting concrete.**

I. INTRODUCTION

Concrete plays a very important role in the present growing construction industry. Cement and other additives are mixed to form concrete. Cement industry has huge effects on environment, usage of energy and economy. The materials may fully or partially replace the OPC which satisfy the necessities of durability and strength characteristics. Among several substitute materials, such as FA, GGBFS, MK, SF, RHA, etc., are some of industrial waste have been well known by the Industry. So, cement replacing by industrial waste or by products is very beneficial with regard to economy, durability, strength and other co-friendly benefits. These materials are now termed as complimentary cementitious materials (CCM).
In this paper the experimental work is carried out to study the effect of replacement of cement by pozzolanic materials. For the study, Pozzolanic materials such as MK and GGBFS are used. The cement is replaced by these pozzolans in various percentage levels such as 5+5%, 10+10%, 15+15% and 20+20%. The binary blends such as MK+GGBFS. The effect of replacement levels of selected pozzolans in concrete are studied by conducting tests on compressive strength.

II. LITERATURE REVIEW

Some of the early researches have examined the use of SCC in addition and replacement of metakaolin and ground granulated blast furnace slag.
Ali kandemir- In this paper the origin of coarse aggregate and mineral admixture carries outmost importance in terms of fresh and mechanical properties of SCC. The effect of two mineral admixture fly ash and lime stone and coarse aggregate- limestone and olivine basalt on fresh and hardened SCC have been investigated within a series of laboratory test.

Mehmet Gesoglu- This paper addressed the permeation properties of SCC with different type and amount of mineral admixture, Portland cement, metakaoline, fly ash, and Ground granulated blast furnace slag were used in binary, tertiary and quaternary cementinious blends to improve the durability characteristic of SCC.

KasimMermerdas- The main object of this experimental investigation is to find out mineral admixture used in Self compacting concrete containing higher permeability resistance than the control mixture.

III. EXPERIMENTAL

Materials Used

***Cement*:-**In this experimental investigation ordinary Portland cement of 43 grade (ACC cement) was used.

***Fine Aggregates*:-**The fine aggregates used in this investigation was Narmada River sand passing through 4.75 mm sieve with specific gravity of 2.52. The percentage of passing is within the limits as Indian Standard Specification. The fine aggregate corresponds to the zone II gradation as per IS 383:1970.

***Coarse Aggregates*:-**Machine crushed broken stone angular in shape was used as coarse aggregates. Twofraction of coarse aggregates were used, 20mm size having specific gravity of 2.84, and 10mm size havingspecific gravity of 2.84.

***Water*:-**Ordinary tape water clean, potable free from suspended particles and chemical substance was used forboth mixing and curing of concrete.

***Chemical Admixture*:-** Chemical admixture or superplasticiser was used in self compactingconcrete. Superplasticiser help us in increase the workability of concrete without addition of water. Use of superplasticiser is economical as the cost of incurred on them is less than the cost of cement saved, this is more so in concrete designed for higher workability.
Table No. 1 :- Properties ofChemical Admixture

Colour	Amber brown
Form	Liquid
Specific gravity	1.24 ± .02
Chloride content	<.02%

***Ground Granulated Blast Furnace Slag*:** In this experimental work, Ground granulated blast furnace slag is received from Bhilai steel plant. In this study physical and chemical composition gives in table no 2.

***Metakaolin*:** In this experimental work, Metakaolin is received from 20micron company,Gujarat(vadodara) India is used. In this study physical and chemical composition gives in table no 2.

Table No. 2 :- Physical Properties of Metakaolin and GGBS

Physical properties			
		Metakaoline	**GGBS**
1	Colour	White	Grey
2	Physical form	Powder	Powder
3	Specific gravity	2.5	2.9

Table No. 3 :-Chemical Properties of Metakaolin and GGBS

Chemical Composition			
		Metakaoline	**GGBS**
1	Calcium oxide (Cao)	0.2-0.8	33.2
2	Silicon dioxide (Sio_2)	50-55	34.4
3	Aluminium oxide (Al_20_3)	42.0	21.5
4	Iron oxide (Fe_20_3)	1.00	0.2
5	Magnesium oxide (Mgo)	0.2-0.8	9.5
6	(So_3)	-	-
7	Potassium oxide (K_20)	0.5-1.2	0.97
8	Loss on ignition %	0.98	1.64

Preparation Of Specimens
The water quantity, cement, fine aggregate and coarse aggregate required for SCC were calculated based on the procedure given in EFNARC. The constant water cement ratio of 0.45. The measurement of materials was done by weight using weighing machine. Water was measured in volume. Concrete was placed in moulds in layers. The cast specimens were removed from moulds after 24 hours and the specimens were kept for water curing.

Calculation of cement and pozzolanic materials for compression strength test is tabulated in Table 3.

Table no. 4:-Mix proportion for different mixes

Mix	**Cement (Kg/m^3)**	**Metakaolin (Kg/m^3)**	**GGBFS (Kg/m^3)**	**Fine Aggregate (Kg/m^3)**	**Coarse Aggregate(20mm size 60% & 10mm size 40%) (Kg/m^3)**	**W/C**	**Superplasticizer (Kg/m^3)**
MIX 0%	450	0	0	856	790	0.45	9.0
MK 5% + GGBFS 5%	405	22.5	22.5	856	790	0.45	8.10

MK 10% + GGBFS 10%	360	45	45	856	790	0.45	7.20
MK 15% + GGBFS 15%	315	67.5	67.5	856	790	0.45	6.30
MK 20% + GGBFS 20%	270	90	90	856	790	0.45	5.40

***Testing Of Specimens*:** For each batch of concrete, 3 cubes of 150mm x 150mm x 150mm size were tested to determine compressive strength of concrete by replacing cement with different pozzolanic materials at various replacement levels.

IV. RESULTS AND DISCUSSIONS

Workability: The fresh state properties like slump flow, T_{500} time, V-funnel and, L-box blocking ratio have been assessed.

Table no. 5:- Workability

S.No.	Mix Discription	Slump Flow (mm)	T_{500} mm (sec)	V-funnel (sec)	L-box Blocking ratio (H_2/H_1)
1.	MK+GGBFS(5%+5%)	680	3.6	8.5	0.83
2.	MK+GGBFS(10%+10%)	689	3.4	8.3	0.82
3.	MK+GGBFS(15%+15%)	690	3.0	8.4	0.80
4.	MK+GGBFS(20%+20%)	695	3.0	8.0	0.78

Compressive strength:

In this study, mix M1 was taken as reference mixes were categorized under one group: Metakaolin and Ground granulated blast furnace mix (MK + GGBFS mix).

Table no. 6:- Compressive strength

S.No.	Mix Discription	Metakaoline(%)	GGBFS(%)	Average Ultimate Compressive Strength(N/mm2) (7 days)	Average Ultimate Compressive Strength(N/mm2) (28 days)
1.	PLAIN	0	0	28.15	38.67
2.	MK + GGBFS	5	5	29.04	39.70
3.	MK + GGBFS	10	10	30.96	41.92
4.	MK + GGBFS	15	15	29.62	39.11
5.	MK + GGBFS	20	20	28.74	38.81

Metakaolin and ground granulated blast furnace slag mix*:* Figure 1 shows the variation in the compressive strength of the SCC mixes when both GGBFS and MK are used as binder materials. The trend shown by the mixes is an inclining one. Though the replacement of GGBFS and MK has shown the increase in the compressive strength but there is a remarkable increasein the compressive strength at 20% replacement of OPC with 10% of GGBFS and 10% of MK.

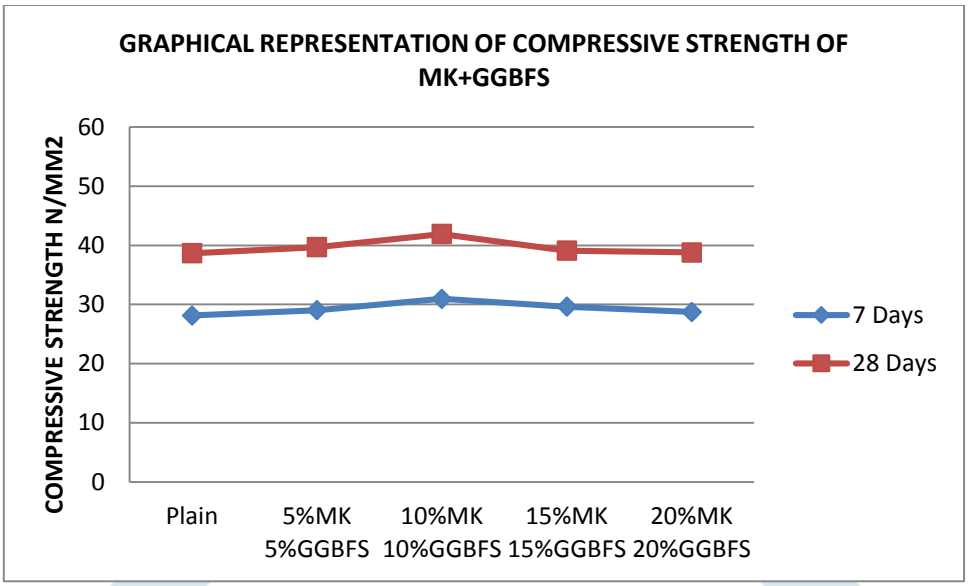

Fig. no. 1 –Compressive strength testing for 7 and 28 days for MK+GGBFS.

V. CONCLUSION

Following conclusion may be drawn based on the experimental study conducted.

1. The replacement of MK+GGBFS in the concrete as partial replacement of OPC increases the 28 days compressive strength signification.
2. The partial replacement of OPC with 10%MK +10%GGBFS was found to be maximum. The increase in 28 days compressive strength at (10+10)% replacement was found to be 8.5% of plain concrete.
3. At 20+20% replacement of MK+GGBFS, the strength is quite near about plain concrete.
4. The optimum compressive strength of 41.92 N/mm^{2}obtained at 10+10% replacement at 28 days ofself compacting concreteconcrete.

The Chemical admixture for all the mixes are attained at 2% SP dosage and constant w/p ratio (0.45).

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