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Comparative Study of Properties of Self Compacting Concrete Made With Ground Granulated Blast Furnace Slag and Metakaoline

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Abstract: Self compacting concrete is an innovative development of conventional concrete. This paper present a comparative study on the use of different material as binder content in Self compacting concrete and their effects on the fresh and hardened properties are checked. different combination of metakaolin and ground granulated blast furnace slag are used as partial replacement of OPC. metakaolin content is varies from 5%, 10%, 15% & 20% and ground granulated blast furnace slag content is varies from 5%, 10%, 15% & 20% by weight of cement. water to binder ratio is maintained at 0.45. strength properties like compressive strength are checked at different days of curing.
Keywords: Metakaolin, Ground granulated blast furnace slag, Superplasticizer, Self Compacting Concrete.

I. INTRODUCTION

Self-Compacting Concrete (SCC), which does not require any external vibration for compaction and flows under its own weight, has revolutionized the construction industry. It was originally developed in Japan during late 1980's. Fluidity and segregation resistance of SCC ensures a high level of homogeneity, minimal concrete voids and uniform concrete strength, providing the potential for a superior level of finish and durability to the structure.

Several different approaches have been used to develop SCC. a simple mixture proportioning system using limited coarse aggregate, super plasticizer and low water-cement ratio providing the potential for high early strength and earlier de-moulding. SCC of high fluidity and segregation resistance is achieved by employing a high Portland cement content and superplasticizer. However, cost of such concretes remarkably increased associated with the use of high volume of Portland cement and chemical admixtures. Wastes and by-products have been introduced to replace the cement content and hence reducing the cost.

The use of mineral admixtures such as fly ash, blast furnace slag, metakaolin and limestone filler reduced the material cost of the SCCs and also improved fresh and hardened properties of the concretes.

This paper presents a comparative study on the use of different binder materials for fresh and hardened properties of SCC, incorporating various combinations of cement, Ground granulated blast furnace slag and Metakaolin. Different combinations were prepared keeping the cement content constant at upto 60%, varying Ground granulated blast furnace slag contents from 0-20% and varying Metakaolin contents from 0-20%.

The effect of replacement levels of selected pozzolans in concrete are studied by conducting tests on compressive strength of concrete.

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, metakaolin, fly ash, and Ground granulated blast furnace slag were used in binary, tertiary and quaternary cementinious blends to improve the durability characteristic of SCC.

Kasim Mermerdas- 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

A. Materials

1) *Cement:*-In this experimental investigation ordinary Portland cement of 43 grade (ACC cement) was used.
2) *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.
3) *Coarse Aggregates:*- Machine crushed broken stone angular in shape was used as coarse aggregates. Two fraction of coarse aggregates were used, 20mm size having specific gravity of 2.84, and 10mm size having specific gravity of 2.84.
4) *Water:*-Ordinary tape water clean, potable free from suspended particles and chemical substance was used for both mixing and curing of concrete.
5) *Chemical Admixture:*- Chemical admixture or superplasticiser was used in self compacting concrete. 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 :- specification of chemical admixture (with the refrence of polygon chemical pvt. Ltd.)

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

6) *Metakaolin* :- In the present investigation work, the metakaolin used is obtained from Gujarat (Vadodara) India. Specific gravity being 2.5. The physical & chemical properties as shown below table 2.
7) *GGBFS* :- Ground granulated blast furnace slag(GGBS) is a by-product from the blast-furnaces used to make iron. GGBS is a highly efficient pozzolonic material and has considerable potential for use in concrete and it is obtained from steel works. Specific gravity being 2.9. The physical & chemical properties as shown below table 2.

Table No. 2 :- Properties of Metakaolin and GGBS

Physical properties			
		Metakaolin	GGBS
1	Colour	White	Grey
2	Physical form	Powder	Powder
3	Specific gravity	2.5	2.9
Chemical composition			
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)	46.0	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

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B. Mix proportions

Table no. 3 The 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	-	-	856	790	0.45	9.0
MK 5%	427.5	22.5	-	856	790	0.45	8.55
MK 10%	405	45	-	856	790	0.45	8.10
MK 15%	382.5	67.5	-	856	790	0.45	7.65
MK 20%	360	90	-	856	790	0.45	7.20
GGBFS 5%	427.5	-	22.5	856	790	0.45	8.55
GGBFS 10%	405	-	45	856	790	0.45	8.10
GGBFS 15%	382.5	-	67.5	856	790	0.45	7.65
GGBFS 20%	360	-	90	856	790	0.45	7.20

Mix 0% - concrete mix without any replacement.
MK 5% - concrete mix with 5% replacement of OPC by metakaolin.
MK 10% - concrete mix with 10% replacement of OPC by metakaolin.
MK 15% - concrete mix with 15% replacement of OPC by metakaolin.
MK 20% - concrete mix with 20% replacement of OPC by metakaolin.
GGBFS 5% - concrete mix with 5% replacement of OPC by GGBFS.
GGBFS 10% - concrete mix with 10% replacement of OPC by GGBFS.
GGBFS 15% - concrete mix with 15% replacement of OPC by GGBFS.
GGBFS 20% - concrete mix with 20% replacement of OPC by GGBFS.

C. Casting, curing and testing

The strength characteristics of concrete with varying percentage of metakaolin and Ground granulated blast furnace slag were studied by casting cubes. The constituents of the concrete viz, cement, fine aggregate and coarse aggregate were mixed to appropriate proportion by adding water. Metakaolin and GGBFS is replace to the cement in different mix in varying proportion as a partial replacement for cement. Moulds for cube of size 150x150x150mm were prepared and concrete was poured in to the mould layer by layer. The specimens were removed from the moulds after 24 hours and then the specimens were cured with water for 7 and 28 days.

IV. RESULTS AND DISCUSSION

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

Table no. 4 Workability

S.NO.	MIX DISCRIPTION	Slump Flow (mm)	T_{500} mm (sec)	V-funnel (sec)	L-box Blocking ratio (H_2/H_1)
1	PLAIN (0%)	670	4.1	12.0	0.88
2	MK(5%)	678	3.8	9.0	0.84
3	MK(10%)	680	3.6	8.7	0.84
4	MK(15%)	685	3.5	8.6	0.83
5	MK(20%)	688	3.2	8.3	0.81
6	GGBFS(5%)	662	3.9	8.8	0.85
7	GGBFS(10%)	665	3.7	8.7	0.83
8	GGBFS(15%)	670	3.6	8.7	0.83
9	GGBFS(20%)	677	3.4	8.3	0.82

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A. Compressive strength:

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

Table no. 5 Compressive strength

S.NO.	MIX DISCRIPTION	Metakaolin (%)	GGBFS(%)	Average Ultimate Compressive strength(N/mm^2) (7 days)	Average Ultimate Compressive strength(N/mm^2) (28 days)
1.	PLAIN	0	0	28.15	38.67
2.	MK	5	-	30.37	41.33
3.	MK	10	-	31.70	43.81
4.	MK	15	-	29.93	40.15
5.	MK	20	-	28.89	39.56
6.	GGBFS	-	5	26.962	38.37
7.	GGBFS	-	10	25.925	37.92
8.	GGBFS	-	15	25.04	36.89
9.	GGBFS	-	20	24.16	36.00

B. Ground Granulated blast Furnace Slag Mix

This study was carried out to obtain the result , tests conduct on blast furnace slag powder modified cement concrete mix. The variation of compressive strength of concrete mix with different proportion of blast furnace slag powder as partial replacement of cement is shown in figure 1 it was observed that 7 days and 28 days compressive strength on 20% replacement of cement reduces about 15% and 6.9% that is from 28.15 N/mm^2 to 24.16 N/mm^2 and 38.67 to 36.00 respectively. From study it can be conclude that as the percentage of GGBFS increases, the strength tends to decreases.

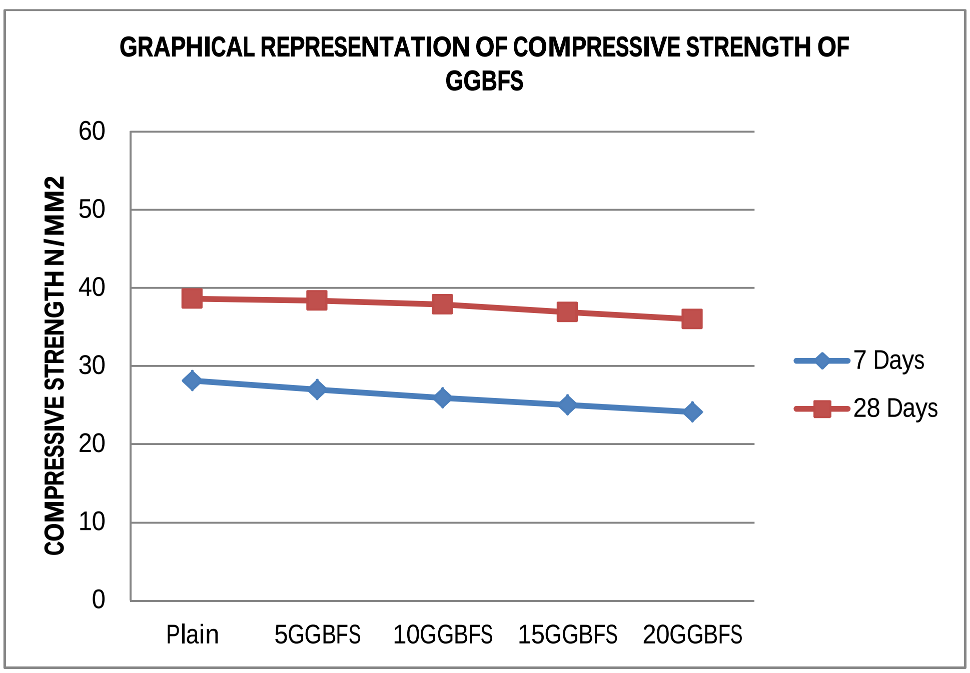

Fig. no. 1 – Compressive strength testing for 7 and 28 days for GGBFS.

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C. Metakaolin Mix

Figure 2 shows the trend followed by the compressive strength in case of MK mixes. Behavior of graph showed that the addition of MK increases the strength of the mix as compared to the reference Mix (0%). The 5% MK replacement increases the compressive strength by 6.9% and 20% replacement increased the strength by 2.3% respectively. The mix prepared at the 10% MK replacement gave an optimal SCC mix with a 13.3% increase in strength.

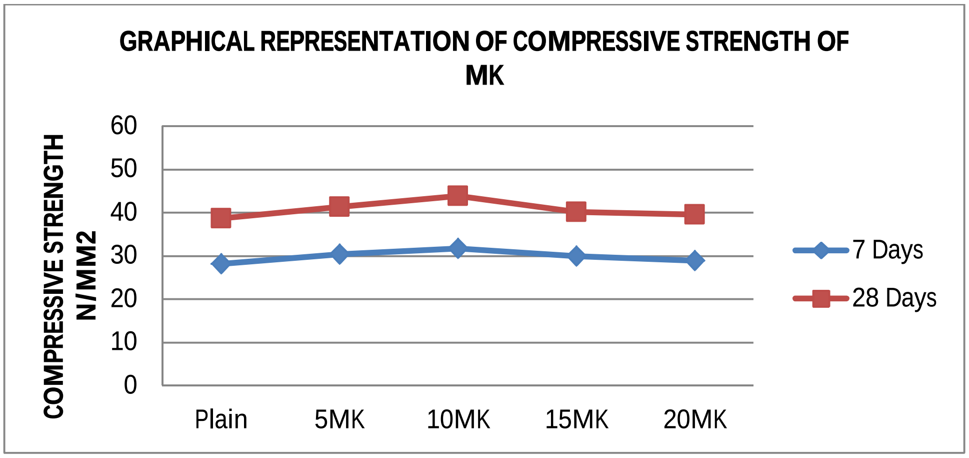

Fig. no. 2 – Compressive strength testing for 7 and 28 days for metakaolin.

V. CONCLUSION

Based upon the work carried out in this investigation, the following conclusions are drawn.

A. The mixing of metakaolin in the concrete as partial replacement of OPC increase the 28 days compressive strength significantly.

B. The replacement of GGBFS as a binder in SCC reduces the compressive strength of GGBFS mixes.

C. Metakaolin and GGBFS was found to be maximum at 10% and 5% replacement respectively and after this the strength is decreases.

D. On replacement of OPC with 20% GGBFS the depreciation in 28 days compressive strength is being near about 5%.

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

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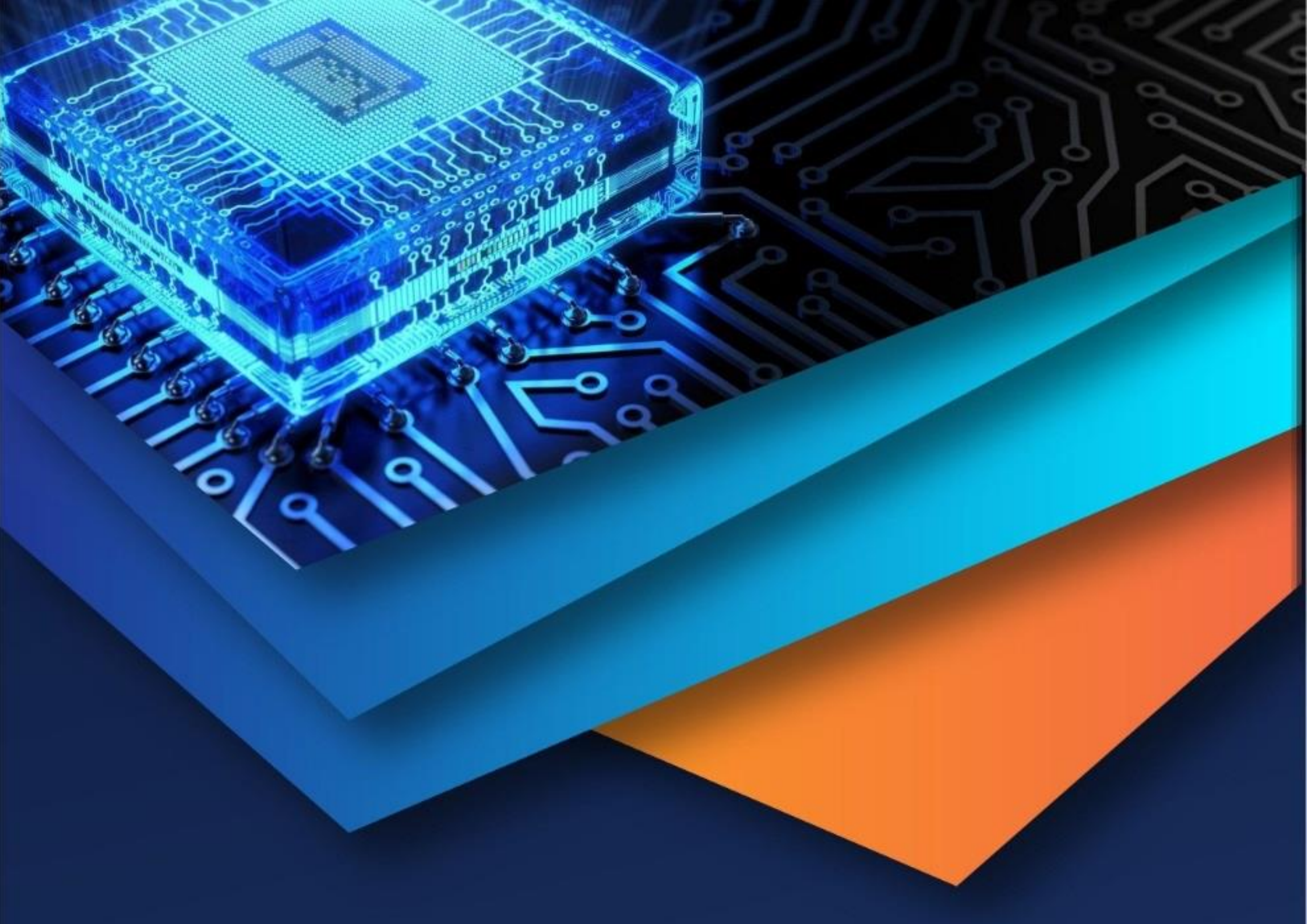

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