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Experimental Studies on Rheological and Durability Properties of Self Compacted Concrete by Using Quaternary Blending

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Abstract

In the production of Self Compacting concrete (SCC), the use of quaternary blend of supplementary cementitious materials (SCM's) has not found enough applications. For this purpose, an effort has been done to present a mix design for M60 grade and M80 grade SCC with quaternary blending of fly ash(FA), ground granulated blast furnace slag(GGBS), silica fume (SF) in accordance with EFNARC guidelines. **Findings**: In this study, cement has been replaced with SCM's from 30% to 50%. Fresh properties of concrete were tested for slump flow, T50 test and U box. The hardened properties of concrete were tested for compressive strength and durability. The tests were performed for 7, 28, 56 and 91 days. The results indicate that the use of quaternary blend has improved the workability, compressive strength and durability properties of specimens than the control specimen. **Application**: The primary contribution is to fill the congested reinforcement and increase the durability and life span of the structure.
Keywords: -Self Compacting concrete (SCC), Fly Ash, GGBS, silica fume, durability.

1 Introduction

SCC is a concrete which flows under its own weight without the need of external vibrator. Due to resistance to segregation and high fluidity it is able to pumped to longer distance and it is not affected by type of reinforcement bars and labor skills. Even if there is congested reinforcement it can fill the voids, and spaces. Clear difference is there between the normal concrete and SCC. The SCM's include FA, GGBS, SF. SCC requires high proportions of SCM's and incorporation of super plasticizer. The SCM's are added to the concrete to enhance the properties of the concrete, and also to improve the mechanical strength, durability and reduce the environmental impact. Now a days, SCC is getting more attention by researchers due to the various construction problems such as inconsistent construction quality, reduce in the durability and life span of the structure, noise pollution due to vibration of equipment, increase cost of labor and materials, inadequate compaction in congested reinforcement, inadequate compaction leads to large number of voids which can reduce the strength and durability of the structures. To overcome these problems special concrete known as Self Compacting Concrete (SCC) is developed. The main reasons for employment of SCC are to shorten the time period, to eliminate the noise during vibration, to ensure compaction of structures even in congested reinforcement. To achieve SCC it should meet the following needs its filling ability, passing ability and resistance to segregation during placing and transportation. The disadvantage of the SCC is no codes are available for the mix design and cost is slightly higher than normal concrete. This research work mainly emphasis on the engineering and durability criteria of SCC using partial replacement of SCM's in the concrete.

2 Material properties

The properties of the materials which were used in this research are as follow **Cement:** - 53 grade OPC cement is used. The properties of cement are confirmed to IS 12269-2013.**Fine aggregate**: - locally available river sand is used. Sieve analysis has been carried out. The results were as per IS 383-1970. River sand is of Zone II. The specific gravity and fineness modulus of the sand is 2.58 and 2.83.**Coarse aggregate**:- Natural aggregate of size 10mm and 20mm are used. The aggregate were tested and sieve analysis has been confirmed to IS 2386(Part 1, 2, 3). The specific gravity and fineness modulus of coarse aggregate is 2.88 and 6.02.**Chemical admixture**: - To reduce the water cement ratio admixture, Sika viscrocrete 2044 is used. The dosage of admixture has been decided by marsh cone test. **Water**:- Fresh water with PH 6.68 is used for casting and curing.

Properties	Silica fume	GGBS	Fly ash
Fineness or surface area	750.16	395	333
Loss on ignition	1.04%	0.65	0.87
Moisture	0.10%	0.38	0.132
Passing on 45 Micron sieve (Wet sieving)	99.20%	-	-
Retention on 45 Micron sieve (Wet sieving)	0.8 %	2.90	3.5
Specific Gravity	2.3		

Table 1 Physical Properties of materials

3 Experimental programme

SCC mix proportions

By conducting various trial mix designs final trial mix has been designed. It satisfied EFNARC guidelines for SCC. Table 1 shows the final mix proportions of each SCC with different percentage of fly ash, GGBS and silica fume. The water cement ratio is 0.28 for M 60 and 0.22 for M 80.

Design mix	**OPC Kg/m^3**	**GGBS Kg/m^3**	**FA Kg/m^3**	**SF Kg/m^3**	**Fine aggregate Kg/m^3**	**Coarse aggregate Kg/m^3**		**Water Lit**	**SP Lit/m^3**
For M60						10mm	20mm		
A0	530	-	-	-	661	457	635	174	3.7
A1	265	106	106	53	661	457	635	174	3.7
A2	235	133	106	53	661	457	635	174	3.7
A3	212	133	133	53	661	457	635	174	3.7
A4	159	159	159	53	661	457	635	174	3.7
For M80									
B0	620	-	-	-	558	458	684	180	4.3
B1	310	124	124	62	558	458	684	180	4.3
B2	279	124	155	62	558	458	684	180	4.3
B3	248	155	1555	62	558	458	684	180	4.3
B4	186	186	186	62	558	458	684	180	4.3

Table 2 Mix Proportion

4 Results and Discussions

4.1 Rheological properties

To ensure the SCC, workability test is carried out. Slump flow, T50 flow and U box are conducted immediately after the fresh mix formed. The procedure of the test was conducted as per the guidelines EFNARC. The slump value was in the range of 652 mm to 710 mm for M60 grade concrete and 670mm to 720mm for M80 grade concrete which was acceptable by the guidelines. The T50 test was 2.4-2.45 sec for M60 grade concrete and 2.5- 2.7 second for

M80 grade concrete which was acceptable as per the guidelines it was 2-5 seconds. The U box test was also satisfying the SCC criteria.

Design Mix	Proportions	Slump flow	T50 Test	U box Test
For M60	FA+GGBS+SF			
A0	0%	652	2.3	20
A1	20%+20%+10%	685	2.35	24
A2	20%+25%+10%	710	2.2	27
A3	25%+25%+10%	675	2.4	25
A4	30%+30%+10%	660	2.45	22
		For M80		
B0	0%	670	2.3	25
B1	20%+20%+10%	690	2.35	27
B2	20%+25%+10%	720	2.2	28
B3	25%+25%+10%	695	2.4	26
B4	30%+30%+10%	685	2.45	25

Table 3 Workability Test

Slump flow of M60 grade concrete was carried out and it satisfies the slump test criteria. The slump flow was 710 mm. According to the EFNARC, the mix design satisfy all the requirements and all under the acceptable criteria.

4.2 Durability properties

4.2.1 Water Permeability Test

Sr No	Mix Type	% of FLY-ASH +GGBS+ SILICA FUME	Water permeability Test (mm)
1.	AO	0%	5.0
2.	A1	20%+20%+10 %	4.1
3.	A2	20%+25%+10 %	3.8
4.	A3	25%+25%+10 %	3.9
5.	A4	30%+30%+10 %	4.0

Table 4 Water Permeability test for M60 Grade Concrete

Sr No	Mix Type	% of FLY-ASH +GGBS+ SILICA FUME	Water permeability Test
1.	BO	0%	4
2.	B1	20%+20%+10 %	3.1
3.	B2	20%+25%+10 %	2.8
4.	B3	25%+25%+10 %	2.9
5.	B4	30%+30%+10 %	3.0

Table 5 Water Permeability test for M60 Grade concrete

4.2.2 Carbonation depth

Carbonation test obtained by various combination of fly ash, GGBS and Silica Fume for M60 and M80 grade concrete is as shown

Table 6 Carbonation Test for M60 Grade of concrete

Sr No	Mix Type	% of FLY-ASH +GGBS+ SILICA FUME	Carbonation Test

1.	AO	0%	19.7
2.	A1	20%+20%+10%	Nil
3.	A2	20%+25%+10%	Nil
4.	A3	25%+25%+*10%	Nil
5.	A4	30%+30%+10%	Nil

Table 6 Carbonation Test for M60 grade concrete

Sr No	**Mix Type**	**% of FLY-ASH +GGBS+ SILICA FUME**	**Carbonation Test**
1.	BO	0%	14.5
2.	B1	20%+20%+10%	Nil
3.	B2	20%+25%+10%	Nil
4.	B3	25%+25%+10%	Nil
5.	B4	30%+30%+10%	Nil

Table 7 Carbonation Test for M80 grade concrete

4.2.3 Mercury Porosity Test

Sample mass (gm)	**1.546**
Sample Density (g)	1
Mercury height (mm)	27.666
Volume at run (mm^3)	471
Weight of dilatometer + mercury + sample (g)	231.955
Capillary mercury height (mm)	0.666

Table 8 Mercury Porosity test input data

Total cumulative volume (cc/g)	**0.41**
Total specific surface area(m^2/g)	8.94
Average pore diameter (Micron)	0.1829

Total porosity (%)	5.768
Bulk density(g/cm^3)	1.40821
Apparent density (g/cm^3)	1.49441
Sample volume correction	0.9401875

Table 9 Mercury Porosity test output data

The Mercury porosity test analyses the pore size and pore diameter and void space between the particles. Results interpret that the total porosity of mercury intrusion is 5.768%, which means very low permeable.

References

PL Domone, HW .Chai, J. Jin, Optimum mix proportioning of self-compacting concrete

Sedran, T., De Larrard, Optimization of self-compacting concrete thanks to packing model, Proceedings of the lst International RILEM symposium on self-compacting concrete, Sweden, (1999), pp 321–332.

PUJA SAIKIA, International Journal of Engineering Research-Online A Peer Reviewed International Journal Articles available online http://www.ijoer.in Vol.3., Issue.4., 2015 (July-Aug).

Rita M. Rathod "To study the effect of varying proportion of Fly Ash and Silica Fume on Fresh and Mechanical Properties of High Strength Self Compacting Concrete". IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 2 Issue 7, July 2015.