TO STUDY THE PROPERTIES OF HIGH PERFORMANCE SELF-COMPACTING CONCRETE USING MICROSILICA & FLY ASH

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Abstract: Self compacting concrete (SCC) is an innovative concrete that doesn't require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The hardened concrete is dense, homogeneous and has same engineering properties and durability as traditional vibration concrete. To deliver HPSCC with ordinary fixings, mineral admixtures like silica fume, fly ash and serviceable specialist Super-plasticizers are additionally utilized. The utilization of mineral admixtures in the solid improves its quality properties as well as sturdiness. The compressive quality are examine finding the ideal utilization of mineral admixture (Silica fume levels 0, 2.04, 4.16, 6.38, 8.7, 11.11 and 13.63 % at 7 days and 28 days of curing). The present examination intends to give configuration blend for High Performance Self-compacting concrete by utilizing Silica fume, fly ash and super-plasticizers.

Keyword: High Performance Self-compacting Concrete (HPSCC), Fly ash, Silica Fumes, Flowability, Compressive Strength, Split Tensile Strength.

I.INTRODUCTION

High performance Self-compacting concrete (HPSCC) exceeds the properties and constructability of normal concrete. Normal and special materials are used to make these specially designed concrete that must meet a combination of performance requirements. HPSCC are made with carefully selected high quality ingredients and optimized mixture designs. HPSCC will have a low water cement ratio of 0.2 to 0.45. Super Plasticizers are usually used to make these concretes fluid and workable. HPSCC almost always has a higher strength than normal conventional vibration concrete. There are many methods of mix design for HPSCC. In this experiment, Indian Standard method IS 10262 : 2019 is used. In this method, the following data is required i.e. Grade of concrete, Maximum size of aggregate, Minimum cement content, Maximum w/c ratio, Workability in terms of slump, Exposure conditions, Maximum temperature at the pouring point, Grading zone of fine aggregate, Type of aggregate, Maximum cement content, Admixture kind, Specific gravity of all the materials used and doses. In this experiment, silica fume is used from 0 % to 13.63 % with addition of constant mass of fly-ash and super-plasticizer on high performance concrete with replacement of silica fume 0 – 13.63 % and the HPSCC mixes are tested experimentally for workability, compression, split tension and flexure and concluded that the performance of the design mixes are very good.

II.RESEARCH SIGNIFICANCE

The main objective of this present investigation is to develop a mix design procedure, for HPSCC by varying the percentage of Silica fume (0 to 13.63%) as well as content of cement at constant dosage of super-plasticizers, fly-ash and other ingredients. Experiments were carried out on HPSCC using the IS 10262 : 2019 Self-compacting concrete mix procedure for M60 concrete to obtain good workability and achieve mechanical properties of the mix design and to find the optimum percentage of Silica Fume. Hence in the present investigation more emphasis is given to study strength characteristics of HPSCC using mineral and chemical admixtures like Silica fume and Super-plasticizer, fly-ash for achieving the better composite and also to increase use of Silica fume and fly-ash to maintain ecology and also encourage the use of silica fume and fly-ash.

III.EXPERIMENTAL PROGRAM

A. DESIGN STIPULATION

1.	Type of Mix	Design Mix
2.	Grade of Concrete	M 60 SCC
3.	Characteristic cube compressive strength @ 28 days	60 Mpa
4.	Current Margin as per MORTH	14 Mpa
5.	Target Mean Strength	74 Mpa
6.	Nominal Maximum size of aggregate	20 mm
7.	Workability in terms of Slump @ placement	Self-Compacting
8.	Degree of quality control	Good
9.	Mode of Pouring	Pump
10.	Cement content (Minimum)	400 Kg
11.	Water Cement Ratio	(0.28 Assumed)

B. SOURCE / TEST DATA FOR MATERIALS

1.	Cement Type / Brand	OPC-53 / Ultratech
2.	Admixture Type / Brand	BASF Masterglenium 8341
3.	Crushed Coarse Aggregates	Crushed Aggregates
4.	Natural sand as fine aggregate	Khijrabad (100% natural)
5.	Micro-silica	Elkem
6.	Specific Gravity / Water Absorption of Materials	
	a. Cement	3.15
	b. Natural Sand	2.61 / 2 %
	c. Coarse Aggregates **20 mm**	2.62 / 0.8 %
	10 mm	2.64 / 1 %
	d. Fly-ash	2.2

7. Gradation of Combined graded coarse aggregates as per IS 383 has been enclosed

20 mm down : 10 mm down = 21 % : 79 %

8. Gradation of all in aggregates as per IS 383 has been enclosed

Coarse Aggregate : Fine Aggregate = 51 % : 49 %

9. Flakiness Index of Coarse Aggregate : 20 mm – 15.20 % & 10 MM – 11.5 %

10. Impact Value of coarse Aggregate : 20.18 %

C. Optimum Mix Design Calculation For Unit Volume of Concrete

1.	Volume of concrete	= 1.00 CUM
2.	Total Cementitious Content	= 620 Kg
3.	Fly-ash	= 120 Kg
4.	Cement	= 450 Kg
5.	Microsilica (Elkem)	= 50 Kg
6.	Volume of Cement	= 0.142 cum
7.	Volume of Fly-ash	= 0.05454 cum
8.	Volume of Microsilica	= 0.0227 cum
9.	Volume of Water	= 0.168 cum
10.	Volume of Admixture	= 0.0049 cum
11.	Volume of all in aggregates	= (1-(0.142+0.05454+0.0227+0.168+0.0049)) = 0.607 cum
12.	Mass of Fine aggregates (Natural Sand)	= e X Vol of F.A. x Sp. Gr. of F.A. X 1000 = 0.607 X 0.49 X 2.61 X 1000 = 776 Kg
13.	Mass of coarse aggregates M1 (20 mm)	= e X Vol of C.A. x Sp. Gr. of C.A. X 1000 = 0.607 X 0.51 X 0.21 X 2.62 X 1000 = 170 Kg
14.	Mass of coarse aggregates M2 (10 mm)	= e X Vol of C.A. x Sp. Gr. of C.A. X 1000 = 0.607 X 0.51 X 0.79 X 2.64 X 1000 = 645 Kg

Table.1 Properties of Fine Aggregate

Sieve Size	Weight Retained in Sieve (Grams)	% Retained	% Cumulative Retained	% Passing
10 mm	-	-	-	100
4.75 mm	55	5.5	5.5	94.50
2.36 mm	90	9.0	14.5	85.50
1.18 mm	143	14.3	28.8	71.2
600 micron	204	20.4	49.2	50.80
300 micron	312	31.2	80.4	19.60
150 micron	178	17.8	98.298.2	1.80
Pan	18	1.8	100	0

Table.2 Properties of Coarse Aggregate

Coarse aggregate	Specific gravity	Bulk density (kg/m^3)	Water absorption (%)
CA	2.62	1535	0.8

Table.3 Properties of Cement

Property	Result
Normal Consistency	30 %
Setting Time Initial Final	 130 min 375 min
Specific Gravity	3.15
Fineness of Cement (By 90 micron sieve)	2 %
Compressive Strength 7 days 2 days	 53 N/mm^2 60 N/mm^2

Table.4 Slump flow class for SCC

Slump-Flow classes Class	Slump-Flow in mm
SF 1	550 to 650
SF 2	660 to 750
SF 3	760 to 850

Table.5 Viscosity class for SCC

Viscosity Classes class	T_{500}, s	V-funnel time in Second
VS1 / VF1	≤ 2	≤ 8
VS2 / VF2	> 2	9 to 25

Table.6 Passing ability classes (L-box)

Passing ability classes (L-box)	Passing ability
PA1	≥ 0.80 with 2 rebars
PA2	≥ 0.80 with 3 rebars

Table.7 Conformity criteria for the properties of SCC

Property	Criteria
Slump-flow class SF1	≥ 520 mm, ≤ 700 mm
Slump-flow class SF2	≥ 640 mm, ≤ 800 mm
Slump-flow class SF3	≥ 740 mm, ≤ 900 mm
Slump-flow class specified as a target value	+/- 80 mm of target value
V-funnel class VF1	≤ 10 s
V-funnel class VF2	≥ 7 s, ≤ 27 s
V-funnel specified as a target value	+/- 3 s
L-box class PA1	≥ 0.75
L-box class PA2	≥ 0.75
L-box specified as a target value	Not more than 0.05 below the target value
Sieve segregation resistance class SR1	≤ 23
Sieve segregation resistance class SR2	≤ 18

D. Test on Fresh Properties of HPSCC: Trial mix 6 gave the satisfactory results for slump flow and 28 days compressive strength with accelerated curing and further tested for the fresh and hardened properties. EFNARC guidelines are followed throught the world to check the rheological properties of self-compacting concrete.

Table.8 Plastic properties of HPSCC Mixtures

Trial Mix	% Replacement of Microsilica	Slump Flow (mm)	T-50 (sec)	L-Box (H2/H1)	U-Box (H2-H1)	V-Funnel (sec)
Trial Mix 1	0	670	7	15	0.90	9
Trial Mix 2	2.04	680	6	14	0.90	8
Trial Mix 3	4.16	685	5	12	0.92	6
Trial Mix 4	6.38	690	5	12	0.95	4
Trial Mix 5	8.7	710	4	11	0.92	3
Trial Mix 6	11.11	740	4	11	0.96	3
Trial Mix 7	13.63	730	4	10	0.96	3

E. Trial Mix Proportions of HPSCC: For HPSCC there is no specific method of design mix. In the present investigation Indian Standard method and as also the available literatures on HPSCC are used. In order to achieve high strength lower w/c ratio is adopted and to achieve good workability super-plasticizer and fly-ash are used. The trial mix proportions of the concrete are shown in **Table 9.** In the present investigation w/c ratio used is 0.27 and dosage of Super-plasticizer is 5.9 Kgs/Cum. The 28 days target mean strength for all mixes was **72.47 Mpa**.

Table 9 Mix proportions of Self compacting concrete (kg/m3)

Trial Mix	Cement (Kg)	Fine Aggregate (Kg)	Coarse Aggregate (20 mm) (Kg)	Coarse Aggregate (10 mm) (Kg)	Water (Kg)	Water cement ratio	Super Plasticizer (Kg)	Silica Fume (Kg)	Fly-ash (Kg)
HPSCC Trial 1	500	776	170	645	168	0.27	5.90	0	120
HPSCC Trial 2	490	776	170	645	168	0.27	5.90	10	120
HPSCC Trial 3	480	776	170	645	168	0.27	5.90	20	120
HPSCC Trial 4	470	776	170	645	168	0.27	5.90	30	120
HPSCC Trial 5	460	776	170	645	168	0.27	5.90	40	120
HPSCC Trial 6	450	776	170	645	168	0.27	5.90	50	120
HPSCC Trial 7	440	776	170	645	168	0.27	5.90	60	120

F. ***Preparation of Test Specimens:*** Six concrete mixes were cast with replacement of 0, 2.04, 4.16, 6.38, 8.7, 11.11 and 13.63 % silica fume with cement, at a 0.27% w/c ratio. The slumps are measured and the slump values increases when the silica fume increases. The cubes are casted and cured in curing pond. At 7 days and 28 days (cubes of size 150 mm x 150 mm x 150 mm) were tested for compressive strength of cubes and the results are shown in Table 10. The compressive strength of cubes are shown in Fig.1

Table. 10 Average value of Cube Strength of concrete (MPa)

Trial Mix	Cube compressive strength (f_{cu}) 7 days	Cube compressive strength (f_{cu}) 28 days
HPC Trial 1	46.2	66.9
HPC Trial 2	53.4	69.2
HPC Trial 3	54.9	71.3
HPC Trial 4	57.09	73.2
HPC Trial 5	58.34	74.8
HPC Trial 6	61.2	76.5
HPC Trial 7	60.32	75.4

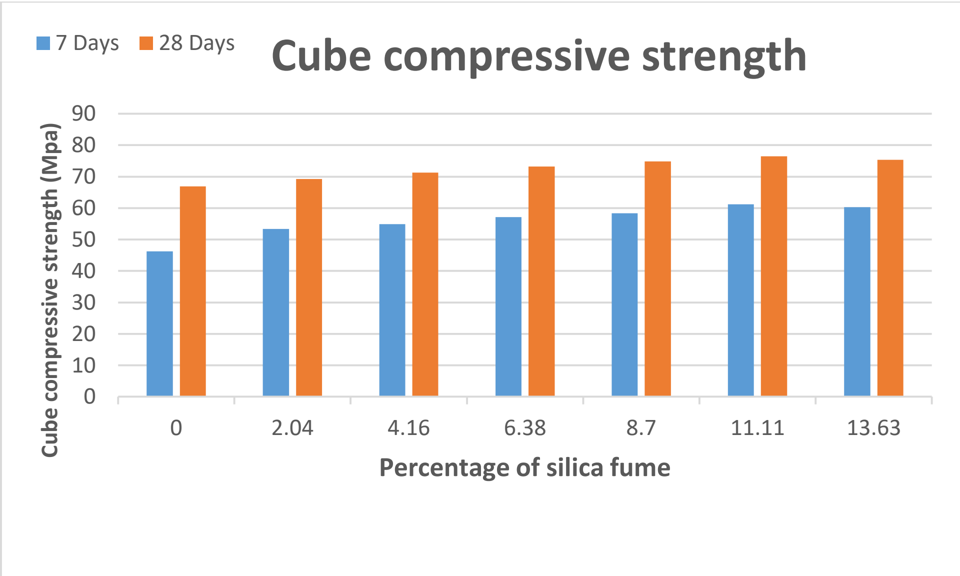

Fig. 1 Percentage of silica fume replacement with cement Vs compressive strength

IV. DISCUSSION OF TEST RESULTS

Replacement of cement by silica fume in HPSCC improved compressive strength up to 14.3 % replacement and after that the strength were reduced both for 7 days and 28 days. This may be due to the fact that the decrease of strength is due to pozzolonic reaction and filler effect of Silica fume.

V. CONCLUSION

The following conclusions can be made on the basis of the current experimental results.

1. A mix design procedure for HPSCC using silica fume and super plasticizer is formulated by Indian Standard method of mix design and available literature on HPSCC.

2. As the silica fume content increases the compressive strength increases up to 14.3 % [**HPSCC Trial 6**] and then decreases. Hence the optimum replacement is 11.11 %.

3. The 7 days and 28 days cube compressive strength ratio of HPSCC is **0.7 to 0.85**.

APPENDIX

Target Mean Strength

$$f_m = f_{min} + ks$$

where

f_m = Target mean strength at 28 days
f_{min} = Characteristics Compressive Strength at 28 days
k = A statical value depending upon the results and number of test
s = Standard deviation
f_m = 60 + 1.65 X 5 = 68.25 Mpa (74 Mpa as per MORTH)

REFERENCES

1. **Patel Yatin H, Patel P.J., Patel Jignesh M, Dr. H S Patel,** "Study on Durability of High Performance Concrete with Alccofine ans Fly-ash". International Journal of Advance Engineering Research and Studies, Vol. 2, Issue 3, pp. 154-157, April-June 2013.

2. **Kamal Mounir M., Mohammed A. Safan, Zeinab A. Etman and Kasem Bsma M.,** "Mechanical properties of self-compacted fibre concrete mixes". Housing and Building Research Centre Journal, Vol. 10, pp. 25-34, 2014.

3. **Hafez E. Elyamany, M Abd Elmoaty. Abd Elmoaty, Basma Mohamed**, "Effect of filler types on physical, mechanical and microstructure of self-compacting concrete and Flow-able concrete", Alexandria Engineering Journal, Vol. 53, pp. 295-307, 2014.

4. **S Dhiyaneshwaran., P Ramanathan., I Bhaskar, and R Venkatasubramani.,** "Study on Durability Characteristics of self-compacting concrete with Fly-ash", Jordan Journal of Civil Engineering, Vol. 7, No. 3, 2013

5. **S Arivalagan, "Experimental Analysis of self-compacting concrete Incorporating different range of High-volumes of class F Fly-ash",** Scholars Journal of Engineering and Technology (SJET), Sch. J. Eng. Tech., Vol. 1(3), 104-111, 2013

6. **E Constantin. Chalioris, N Constantine. Pourzitidis**, "Self-compacting concrete Jacketing – Test and Analysis", AASRI Conference on modelling, Identification and Control AASRI Procedia, Vol. 3, pp. 624-629, 2012.

7. **Hameed Ali Hussein,** "Effect of Super-plasticizer Dosage on Workability of Self-compacting concrete", Diyala Journal of Engineering Sciences, Vol. 5, No. 2, pp. 66-81, December 2012.

8. **Dubey Sanjay Kumar and Chandak Rajeev, Dept. of Civil Engineering, Jabalpur Engineering College, Jabalpur, India,** "Development of Self Compacting concrete by use of Portland Pozzolana Cement, Hydration Lime and Silica Fume", ISCA Journal of Engineering Sciences ISCA J. Engineering Science., Vol. 1 (1), pp. 35-39, July 2012.

9. **Arediwala M. A . F, Jamnu M.A.;** "Relation between Workability and Compressive Strength of Self-Compacting Concrete", International Journal of Advance Engineering Research and Studies.

10. **Mohamed Heba A., "Effect of flyash and silica-fume on compressive strength of self-compacting concrete under different curing conditions",** Ain Shams Engineering Journal, Vol. 2, pp. 79-86, 2011

11. **G. Zoran, D. Iva, T. Gordana, "Properties of Self-Compacting Concrete with different Types of Additives",** Series: Architeture and Civil Engineering Vol. 6, 6 No , pp. 173-177 2008

12. **Khaleel O.R., S. A. Al-Mishhadani, and Razak H. Abdul,** "The Effect of Coarse Aggregate on Fresh and Hardened properties of self-compacting concrete (SCC)", The Twelfth East Asia-Pacific Conference on structural Engineering and Construction.

13. **Bassuoni M.T., Nehdi M.L.,** "Resistance of Self-Consolidation concrete to sulphuric acid attack with consecutive pH reduction", Cement and Concrete Research, pp 1070-1084

14. **Gaywala N R, Raijiwala D B,** "Self Compacting Concrete: A Concrete of Next Decade", Journal of Engineering Research and Studies.

15. **Mustafa Sahmaran and I. Ozgur Yaman**, "Hybrid fiber reinforced self-compacting concrete with a high-volume coarse fly-ash", Construction and BuildingMaterials, 21, 2007, pp. 150-156

16. **N. Krishna Murthy, Narasimha A V. & Rama I. V. V.** Reddy "Micro-level studies on self compacting concrete", Internation Journal of Civil, Structural, Environmental & Infracture (IJCSEIEFD).

17. **C. Nitish,** "Properties of SCC containing Fly-ash and Silica Fume".

18. **Neville A.M.,** "Properties of Concrete: Sergio E. Gomez, Second Edition.

19. **M.S. Shetty**, **"Concrete Technology",** S.Chand and Company Ltd. 2008

20. "The European Guidelines for Self-Compacting Concrete **(EFNARC**) May 2005.

21. "Plain and Reinforced concrete- Code of practice (Fourth Revision) IS 456:2000"

22. IS: 10262 "Concrete Mix Design"