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An Experimental Study on Self Compacting Concrete

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Abstract: ***Self-compacting concrete is a fluid mixture suitable for placing in structures with congested reinforcement without vibration. Self-compacting concrete development must ensure a good balance between deformability and stability. Also, compactibility is affected by the characteristics of materials and the mix proportions; it becomes necessary to evolve a procedure for mix design of SCC. The paper presents an experimental procedure for the design of self-compacting concrete mixes. Locally available coarse aggregate of size 20 mm and 12.5 mm, M sand as fine aggregate used in this experimental work. Water binder ratio was fixed as 0.31.Alccofine used as cementitious material in addition of cement. Different trail mixes were prepared with different C.A:F.A and addition of increasing percentage of super plasticizer for obtaining better SSC mix. The test results for acceptance characteristics of self-compacting concrete such as slump flow, V-funnel and L-Box are presented. The cube specimens of size 150mmX150mmX150mm are prepared for compressive strength concrete mixes. The strengths were determined at the age of 7 and 28 days of curing period.***

Keywords: Self compacted concrete, Alccofine, super plasticizer, slump flow

1. Introduction

Self-Compacting Concrete (SCC), which flows under its own weight and does not require any external vibration for compaction, has revolutionized concrete placement. SCC, was first introduced in the late 1980's by Japanese researchers is highly workable concrete that can flow under its own weight through restricted sections without segregation and bleeding. For SCC, it is generally necessary to use super plasticizers in order to obtain high mobility. Adding viscosity modifying admixture can eliminate segregation. It becomes necessary to evolve a procedure for mix design of SCC. Okamura and Ozawa have proposed a mix proportioning system for SCC. One of the limitations of SCC is that there is no established mix design procedure yet.

2. Objective

To develop the mix design of self compacting concrete to achieve good strength

3. Literature Review

Ozawa *et al.* (1989) focused on the influence of mineral admixtures, like fly ash and blast furnace slag on the flowing ability and segregation resistance of self-compacting concrete. They found out that on partially replacement of OPC by fly ash and blast furnace slag the flowing ability of the concrete improved remarkably. He concluded that the best flowing ability and strength characteristics 10-20% of fly ash and 25-45% of slag cement by mass.

Domone and His-Wen (1997) performed a slump test for high workability concrete. A beneficial correlation between the slump values and flow was obtained from the laboratory test. It showed satisfying value of the slump flow.

Xie*et al.* (2002) presented the preparation technology of high strength self- compacting concrete (SCC) containing ultrapulverised fly ash (UPFA) and superplasticizer (SP).Various parameters of concrete were selected namely good workability, high mechanical properties and high durability and SCC was developed. There was low slump loss in the fresh SCC mixture. The workability of high strength SCC containing UPFA and SP can be evaluated by the method of combining slump flow and L-box test. Slump flow was 600-750 mm. Flow velocity of L-box test was 35-80 mm/sec.

Khatib (2008) investigated the properties of self-compacting concrete prepared by adding fly ash (FA). FA was used as a replacement for Portland Cement (PC). PC was replaced 0-80% by fly ash. For all the mixes water binder ratio was maintained as 0.36. Strength properties as well as the workability, shrinkage, absorption and ultrasonic pulse velocity were studied in this research. From the observations it was concluded that 40% replacement of FA resulted in strength of more than 65 N/mm2 at 56 days. On increasing the amount of fly ash the high absorption values were obtained and absorption of less than 2% was exhibited.

4. Methodology

Materials were collected locally and the laboratory tests conducted on cement fine aggregate and coarse aggregate. After completion of laboratory tests on materials the trail mixes were prepared for M60 grade concrete. The cube specimens were prepared for 7 and 28 days of curing period. The sizes of cube specimens were 150mmX150mmX150mm for determining compressive strength .The flow ability, passing ability and filling ability tests were conducted by slump flow test , L- Box test and V-funnel tests respectively. Strength tests were conducted on hardened concrete after 7and 28days curing period. The average strength of three

cube specimen results was taken in each mix for strength evaluation. From the final results we had done discussions and finally concluded the present work.

5. Experimental Program

Different trail mixes were prepared for obtaining better workability and strength. Coarse aggregate of sizes 20 mm, 12.5mm and M sand as fine aggregate used in different percentages for each mix. Water binder ratio 0.31 was fixed for all mixes. Alccofine was used as cementitious material in addition to cement. Super plasticizer BASF MASTER GLENIUM SKY 8638 was used for better workability and strength.

Table 1: Mix proportions for different mixes

Material	TM-1	TM2	SSC-1	SSC-2	SSC-3	SSC-4	SSC-5
Cement	450	450	450	450	450	**450**	450
GGBS	90	90	90	90	90	**90**	90
Alccofine	20	20	20	20	20	**20**	20
CA:FA	48:50	49:51	50:50	51:49	52:48	**53:47**	54:46
W/B	0.31	0.31	0.31	0.31	0.31	**0.31**	0.31
Super plasticizer	0.1%	0.3%	0.5%	0.7%	0.9%	**1.0%**	1.2%

5.1 Steps taken in the mix proportioning: final mix design

A) Target Mean Strength

1) Target mean strength for M60 grade concrete
   fck* = fck + Ks fck* = 60 + 1.65×5.0 = 68.25 N/mm^2
   Where,
   K = probability factor for various tolerances (5%) = 1.65
   S= Standard deviation for different degrees of control (Good) =5.0
2) The water cement ratio required for the target mean strength (From IS 456-2000) of68.25 N/mm^2 is 0.31.
   Selection of water content
   From IS10269-2009(Table-2) max water content for 20mm =186 kg. (for 20-50 mm slump)
3) Estimated water content for 150 mm slump = 186+{(12*186)/100}=208.32 Kg.

B) Mix calculation with GLENIUM SKY8638 SUPER PLASTICIZER

Based on trails with super plasticizer, water content reduction of 16% has been achieved

208.32 x 0.16 = 33.33

Hence the arrived water content = 208.32-33.33=174.98 (consider 174 liters)

C) Calculation of cementitious material

W/C=0.31
Cement= w/0.31=174/0.31=561.2 kg
(consider 561 kg.)
From Table-5 of IS 4566-2000 , minimum cement content for severe exposure condition is 320 Kg/m^3

Total cementitious material

1) Cement =450kg.(80.35% in total weight of cementitious material)
2) GGBS=90 Kg(16.07% in total weight of cementitious material)
3) ALCCOFINE=20Kg.(3.57% in total weight of cementitious material)

D) Quantities of ingredients (By absolute volume method)

i) Actual cement used= 450kg/m3
ii) w/c fixed = 0.31
iii) Absolute volume of cement = weight of cement/(specific gravity X 1000) =450/(3.15X1000)=0.144
iv) Absolute volume of air =0.02
v) Absolute volume of water=174/(1X1000)=0.174
vi) Absolute volume of GGBS=90/(2.85X1000)=0.0315
vii) Absolute volume of ALCCOFINE= 20/(2.80X1000)=0.0071
viii) Total volume of coarse aggregate and fine aggregate used= 1- (0.144+0.02+0.174+0.0315+0.0071)=0.624 m^3
ix) The corrected sand content as % of total aggregate by absolute volume = 58%-11.4% = 46.4%

E) Determination of coarse and fine aggregate contents

V= [W/SW+C/SC+ Fa/ (P×SFA)]×1/1000;
V= [W/SW+C/SC+ Ca/ ((1-p)×SCA)]×1/1000;
Here W= weight of water
C= weight of cement
Fa = weight of fine aggregate
Ca = weight of coarse aggregate

S.no.	*Name of Test*	*Result*
1	Fineness of Cement	1.9%
2	Specific gravity of Cement	3.15
3	Consistency of cement	32%
4	Initial setting time of cement	120 minutes
5	Finall setting time of cement	345 minutes
6	Specific gravity of GGBS	2.80

SW= specific gravity of water
SC= specific gravity of cement
SCA= specific gravity of coarse aggregate
SFA= specific gravity of fine aggregate

From above equations
1= [174/1 + (450/3.15+90/2.85+20/2.8)+Fa / (0.464×2.72)]×1/1000.
Fa (M sand)=806.94 kg/ m^3 =807kg/ m^3
1= [174/1 + (450/3.15+90/2.85+20/2.8)+Ca / (1-0.464)×2.66]×1/1000.
Ca =925 kg/ m^3 [20mm – 814 Kg(88%) & 12.5 mm–111Kg (12%)]

Table 2: Final Mix proportion for SSC-4

S.no.	Name of Test	Result
1	Fineness modulus of M sand	2.32
2	water absorption of M sand	0.917%
3	Specific gravity of M sand	2.66

Cement+GGBS+ Alccofine (Kg.)	Msand (Kg.)	Coarse aggregate (Kg.)		Water (liters)
		20mm	12.5mm	
560	807	814	111	174
1	**1.44**	**1.65**		**0.31**

S. No.	Trail Mix	Slump flow (mm)	T_{50cm} (sec)	V-funnel T_f (sec)	V-funnl T_{5min} (Sec.)	L-Box Blocking ratio (H_2/H_1)
1	TM-1	400	-		-	-
2	TM-2	670	5.0	39	70	0.10
3	SSC-1	696	3.0	12	15	0.30
4	SSC-2	676.7	3.5	11	12.5	0.90
5	SSC-3	713.3	2.0	10	11	0.95
6	SSC-4	660	4.5	8.0	9	0.90
7	SSC-5	670	5.0	8.0	9	0.67

Total aggregate = coarse aggregate + fine aggregate = 925+807=1732 Kg.

Percentage of coarse aggregate in total aggregate = 53%
Percentage of fine aggregate in total aggregate = 47%

F) Super plasticizer: BASF MASTER GLENIUM SKY 8638 = 1% of cementitious materials = 5.6Kg
The below table gives the recommended values for different tests given by different researchers for mix to be characterized as SCC mix.

Table 3: Workability ranges of SSC

Sr. No.	Property	Range
1.	Slump Flow Diameter	500-700 mm [14]
2.	T_{50cm}	2-5 sec [14]
3.	V-funnel	6-12 sec [5]
4.	L-Box H2/H1	≥ 0.8 [10]

6. Results and Discussions

6.1 Results

From the laboratory tests the following results are obtained

Table 4: Test results on Coarse aggregate

S.no.	Name of Test		Result
1	Water absorption of C.A	20mm	0.82%
		12.5mm	0.91%
2	Specific gravity of C.A	20mm	2.66
		12.5mm	2.71

Note:
T_{50cm}: time taken for concrete to reach the 500 mm spread circle
T_f : V-funnel flow time after keeping the concrete in funnel for 10 sec
T_{5min}: V-funnel flow time after keeping the concrete in funnel for 5 min
H1, H2: Heights of the concrete at both ends of horizontal section of L-box after allowing the concrete to flow

6.2 Discussion

Mixes TR-1 & TR-2 were initial trials to obtain SCC mix. None of the SCC characteristics was found in the mixes. The consistency and workability of SCC1 to SCC5 satisfied slump flow property but SCC3 was the only mix to have slump value 713.3 mm thus satisfying both slump flow and time property of T_{50} cm as 2 sec. In addition, all the mixes SCC1 to SCC5 have the V-funnel time T_f between 6-12 sec and V-funnel time T_{5min} within the range of T_f +3. The L-Box blocking ratio H2/H1 could not be satisfied for SCC1 and SCC5.

Table 7: Workability test results of SSC

7. Conclusion

- The SCC-1 to SCC-5 mixes can be easily used as medium strength SCC mixes, which are useful for most of the constructions.
- The proportions for SCC-3 mix satisfying all the properties of Self-Compacting Concrete can be easily used for the development of medium strength self-compacting and for further study

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