Effect on Fresh Properties of Self-Compacting Concrete Produced by using Cementitious materials, Ultrafine Concrete Additives and Fourth Generation Super-Plasticizers"

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ABSTRACT

Self Compacting Concrete(SCC) is the flowing concrete which does no longer requires any vibration for its compaction & for achieving its homogeneity .This paper highlights the effects of various mixes on plastic stage properties such as flow -ability, filling ability, passing ability, segregation resistance etc. Mixes were prepared by using combinations of cementitious materials – OPC & PFA, ultrafine concrete additive, Metakaolin,Micro silica and fourth Generation Super-plasticizers admixture pure Polycarboxylate ether (PCE base). First of all, optimized percentage dose of ultrafine concrete additive was finalized and same percentage was used for further trials. Water to binder ratio and chemical admixture dosage are kept constant i.e 0.26 & 0.65% respectively, for all trials. Initial flow of SCC was observed. Mixes in plastic stage, were then tested for above mentioned properties. From the experimental Investigation, it is observed that ultrafine concrete additive used in four-blend mix has been proved best in almost all parameters of workability.

KEY WORDS:- *SCC,OPC, PFA, Metakaolin, Microsilica, PCE ,Ultrafine Concrete Additive*

1. INTRODUCTION:-

Self Compacting Concrete (SCC) was invented in 1980s.in Japan. It became evolved to triumph over deficiency of professional manpower & issues of placing concrete in the places in which there is congestion of steel & external vibration isn't always viable. After so much experimentation, it is proved that, SCC not only reduces the requirement of manpower & solves the placing of concrete at congested places but also results in more durable concrete.

The main reasons of popularity of SCC are speedy construction, better placing even in the congestion of steel bars, requirement of less manpower, better finish, higher retention, improved durability. less noise pollution due to absence of compaction etc

Many admixtures (mineral/chemicals) have been used in the producing SCC but still SCC is lacking in the properties such as flow ability & durability to some extent & this is the reason why application of SCC in construction practices is still less. Aim of present study is to achieve increased workability parameters of SCC & thereby its wide application in construction practices. Self compacting Concrete must be highly workable as it does not require any external compaction so its interim workability works actively in overall concreting performance.

2. EXPERIMENTAL PROGRAMME:-

In this study, only initial flow of workability is being considered. Analysis of flows at subsequent retention periods & evaluation of strength & durability parameters are in process of investigation.

2.1 Materials:-

Following table shows various materials used with its brand & source.

Table.1 Materials & Its Sources

S.N	Material Ingredients	Brand/ Source
1	Ordinary Portland Cement	Ambuja Cement Ltd.– (OPC 53 Grade) Kodinar, Gujarat
2	Pulverized Fly-Ash	Jaycee Resources, JSW Plant – Ratnagiri
3	Meta-Kaoline	1. Kaomine, Gujarat 20 Microns, Gujarat
4	Micro-silica	1. Elkem India, China/ Norway 2. Jaycee Resources, China
5	Ultrafine Concrete additive	Gujarat
6	Admixture PolyCarboxylate Ether (PCE)	Sika-Viscocrete 5210NS (Sika India Ltd.),Navi Mumbai & Jagadia-Gujarat
7	Crushed Sand	Local – Vasai-Virar
8	Coarse Aggregates	Local – Vasai-Virar
9	Water	Tanker – Mumbai

2.2 Mix Design:- As per EFNARC guidelines (8.4), there is no standard method of mix design, applicable for designing SCC mixes. However Concrete Technologists & ready mixed concrete Professionals have developed their own mix proportioning methods. In this study also, such proportioning has been implemented for preparing SCC mixes. For fresh plastic stage concrete, EFNARC guidelines also have been followed. As ultrafine additive was new material, its compatibility with all other ingredients was observed by conducting first three trials by varying its percentage in concrete mix. Optimized % content of additive was then finalized & same was used for further all trials. It was finalized on the basis of flow, early age as well as later age strength of sample. Thereafter for all further trials, following parameters were kept constant.

Water to binder ratio - 0.26 Aggregate to Cement ratio - 2.49 Admixture dosage - 0.65%

Table.2 Mix Proportioning for M60 (M70-45days) 1m3 mix

Proportioning of SCC M60 (M70-45days) for 1M^3 mix		
Weight of total Cementitious (CC) = 659Kg.	**Ingredients**	**%**
	Cement	70.1
	Fly Ash	24.6
	Metakaoline/Micro silica	3.8
	Ultrafine Additive	1.5
	Crushed Sand	47.5
	Aggregates (10mm)	52.5
	Admixture (PEC)	0.65
	Water/Cement	0.26
	Aggregate/Cement	2.49

- Trial Mix no.I – Four blend –OPC+PFA+ Metakaolin+ Ultrafine additive (1.14%)
- Trial Mix no.II – Four blend –OPC+PFA+ Metakaolin+ Ultrafine additive (1.52 %)
- Trial Mix no.III – Four blend –OPC+PFA+ Metakaolin+ Ultrafine additive (1.82%)

On the basis of slump flow & early age & later age compressive strength, ultrafine additive 1.52% of total cementitious material(Trial no.II) was observed best amongst three trials & therefore for further all trials same content of additive was used in mixes.

- Trial Mix no.IV - Metakaolin without Ultrafine additive

- Trial Mix no.V-- Microsilica (Elkem) with Ultrafine additive
- Trial Mix no. VI -- Microsilica (Local) with Ultrafine additive
- .Trial Mix no.VII – Microsilica(Elkem) without Ultrafine additive
- Trial Mix no.VIII-- Microsilica(Local) without Ultrafine additive

2.3 Tests Conducted :-

Performance of SCC is evaluated by its ability to flow, ability to pass, ability to fill & resistance to segregation etc. Any single method is not enough for evaluating workability parameters & hence concrete technologist always advised to conduct various test methods such as flow test,V-funnel, L-box, J-Ring etc. Following tests were conducted to assess properties of fresh self compacting Concrete.

Table.3 Tests conducted for assessment of various properties

S.N.	Test Conducted	Property Evaluated
1	Slump flow	Filling Ability
2	T_{50} flow	Filling Ability
3	V-funnel T_0	Filling Ability
4	V-funnel T_5	Segregation Resistance
5	J-Ring	Passing Ability
6	L-Box	Passing Ability

Table 4. Recommended Limits for Different Properties (EFNARC 2005)

S.N.	Test	Range
1.	Slump Flow	500-700 mm
2.	T_{50cm}	2-5 sec
3.	V-funnel T_0 (seconds) V-funnel T_5 (seconds)	6-12 sec 9-25 sec.
4.	L-Box (h_2/ h_1)	≥ 0.8
5.	J-Ring (diameter of spread)	500-700mm.

2.3.1. Test Procedures :-

2.3.1.1 Slump Flow Test & T_{50} Test:- (EFNARC 2005 Annexure B-1Part-B1)

It is most commonly used test for assessment of filling ability of concrete.

Stepwise procedure is mentioned below:-

- Position the slump cone at the leveled base.
- Pour the concrete with a scoop from top without tamping to fill the slump cone completely. Strike off excess concrete.
- Raise the Cone vertically without any jerks & allow the concrete to flow freely.
- Count the time required for concrete to cover 50 cm.diam.spread circle(T_{50}) Start counting the time, the moment cone is lifted.
- Measure the average flow diameter (D_1+ D_2/2) of concrete after it stops flowing. This value is slump flow value in mm. Slump flow is the mean diameter measured in two Perpendicular directions of the spread.
- Higher slump value indicates greater flow ability & lesser resistance to segregation.

2.3.1.2 V-Funnel Test:- (EFNARC 2005 Annexure B-2 Part-B2)

Figure 1. V- Funnel Test apparatus

This test is designed to assess the flow ability & segregation resistance of SCC.
Stepwise procedure is mentioned below :-

- Position the V- funnel along with supporting arrangements on leveled ground.
- Moisten the internal surface thoroughly with wet sponge & close the trap door.
- Pour the concrete from the top of the funnel without any external efforts either to compact or level it.
- Open the trap door as quickly as possible after filling the funnel without giving any jerk.
- Note the time required to empty the funnel completely in seconds, which is T_0
- Repeat the same procedure with the only change that trap door is opened after 5minutes of filling the funnel completely& note the time requires to empty the funnel completely in seconds, which is T_5.

2.3.1.3 L- Box Test:- (EFNARC 2005 Annexure B-3 Part-B-3)

This test is performed mainly to evaluate passing ability of SCC. The apparatus consist of "L" Shaped rectangular box section. Concrete is made to pass through the obstructions of known clearances.

Figure 2. L- Box Test apparatus

Stepwise procedure is mentioned below :-

- Fill Vertical section of box fully with concrete.
- Lift the gate vertically & allow the concrete to flow into horizontal section through steel bars placed.
- When concrete stops flowing, measure the height of concrete at the end of horizontal section (h_2) & the height of concrete in vertical section (h_1)

- The ratio of (h_2/ h_1) is blocking value which is measure of passing ability of SCC. Blocking value of SCC should be in between 0.8 &1.0. I.
- If ratio is far less than 0.8, it shows viscosity is simply too high & if it is close to 1,it suggests Viscosity on the lower aspect however in a suitable variety.

2.3.1.4 J -Ring Test:- (As per guidelines of TESTING-SCC by G. DE SCHUTTER)

Figure 3. J-Ring Test apparatus

This method is conducted for estimating passing ability of SCC. Actually this method is similar to slump cone method. Only difference is that, in J-Ring test, Concrete has to pass through the obstacles created by steel bars. J-Ring diam.is about 300mm.

Test Procedure is as given below:-

- Place J-Ring over leveled base, in a central position.
- Put slump cone inside the ring in inverted position.
- Fill the cone completely with the concrete with a scoop. Strike off excess concrete.
- After a short rest (no extra than 30 seconds for cleaning and checking the wet surface), raise the cone Vertically from the base plate in motion. Cone will be lifted in such a manner that the concrete is allowed to drift out freely without obstruction from the cone. Start the Stop Watch from the moment the cone loose contact with the base plate. The test is completed when the flow of concrete stopped.
- Measure the final spread diameter in two perpendicular directions.

3. RESULTS & DISCUSSIONS:-

Table no.5 Values of Properties of Fresh S.C.C

Tests		Trial Mix I	Trial Mix II	Trial Mix III	Trial Mix IV	Trial Mix V	Trial Mix VI	Trial Mix VII	Trial Mix VIII
Slump flow	T-50 (Seconds)	5.8	4.7	4.4	3.6	3.2	4.3	3.9	4.6
	Initial Flow (mm)	710	680	645	600	600	650	635	680
V-funnel T_0 (Seconds)		19	12	11	10	11	13	15	14
V-funnel T_5 (Seconds)		23	14	13	12	12	15	18	17
J- Ring Spread Diam.(mm)		550	670	635	580	585	625	680	700
L- Box (h_2/h_1)		0.72	0.90	0.86	0.91	0.86	0.87	0.82	0.84

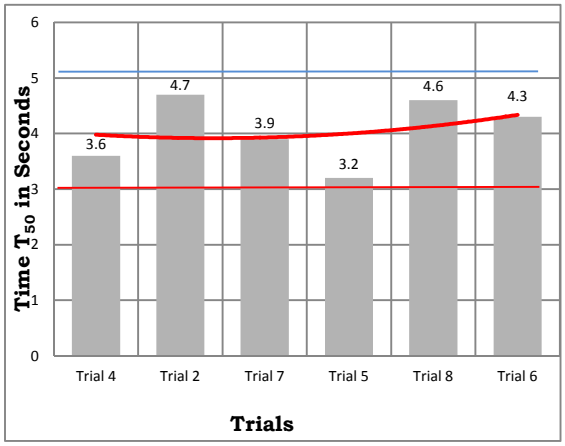

Figure 4. Slump Flow Test T_{50} Values

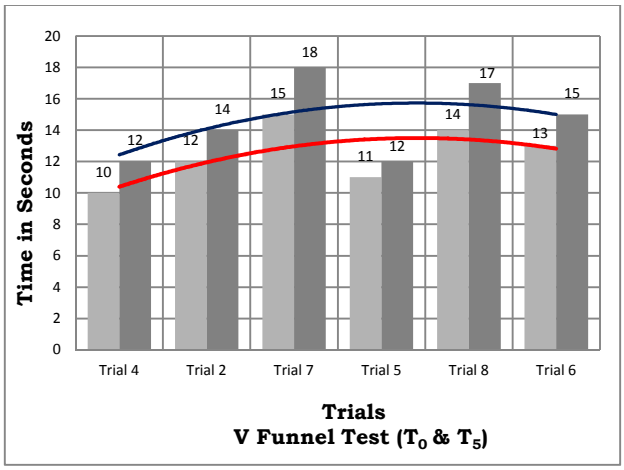

Figure 5. V-Funnel Test T_0 &T_5 Values

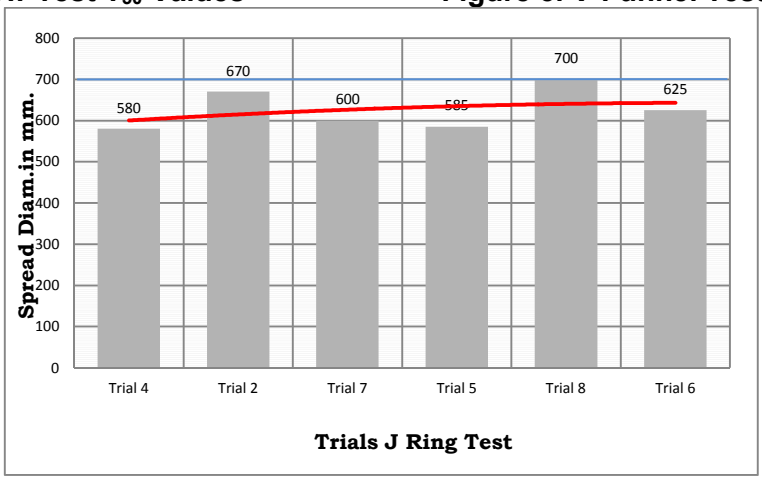

Figure 6. J-Ring Final Spread Diameter Values

Table no.5 shows test results of various workability tests performed on SCC mixes of various combinations.

Slump flow Test ---Initial flows of all trials were found in the standard range mentioned in Table no.4. Higher flow was observed for Trial-I

In **T_{50} Test**, lesser time was recorded in case of blend of micro silica with ultrafine additive (Trial no.5).

V-funnel Test – Filling ability of all most all the combinations were found satisfactory.

If T_5 value is more than 3 seconds over T_0 value then there are chances of segregation of SCC mix but except Trial no. I, T_0 & T_5 values of all trials were found in range.

L- box Test – Except Trial no. I, blocking value of all the trials was desirably found more than 0.8, which indicates low viscosity.

J-Ring Test – Larger the spread diameter better is the passing ability. Blend of Metakaoline & Ultrafine additive had recorded flow of 680mm that is exceptionally good.

4. CONCLUSION:-

Following conclusions can be drawn from this study:-

i) As far as flow is concerned, Ultrafine additive has been proved best & it is more compatible with Metakaoline in blend.

ii) Higher flow given by blend of Metakaoline & Ultrafine additive indicates its greater flow-ability & lesser resistance to segregation along with better results in retention of concrete.

iii) The blend of Metakaoline & Ultrafine additive has performed better with PCE admixture with specified doses than blend of Micro-silica & Ultrafine additive.

iv) As far as passing & filling ability is concerned, combination of Micro -silica & Ultrafine additive found best.

v) It is found that, for reaching better workability, content of Ultrafine additive in SCC blend, cannot be used more than1.52% of total cementitious materials.

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