THE EFFECT OF MEASURING PROCEDURE ON THE APPARENT RHEOLOGICAL PROPERTIES OF SELF-COMPACTING CONCRETE

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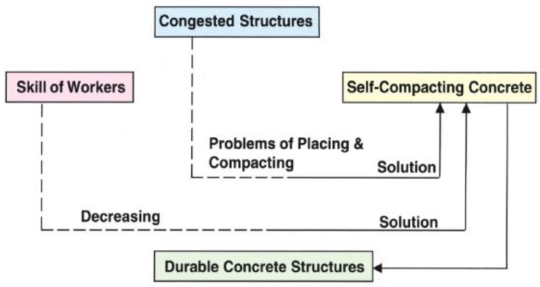
ABSTRACT:

Self compacting concrete was first developed in 1988 to achive durable concrete structure. Various investigation has been carried out and this type of concrete has been used in large structure. Investigation for establidhing a rational mix-design method and self-compactability testing methods have been carried out from the viewpoint of making self-compacting concrete.

INTRODUCTION

Self compacting concrete was first developed in japan around the year 1988. Professor H. Okamura from the university of Tokyo, japan is mainly responsible for initiating the development of such concrete. The need of development of such concrete arose from the scarcity of skilled manpower in japan during this period. It was developed to over come deficiency of skilled manpower and problem of placing and compacting congested civil engineering structures. Subsequently it has been observed that scc not only reduces the requirement of manpower, both skilled and unskilled, but also result in more durable concrete as illustrated in figure bellow.



The use of Self–compacting Concrete (SCC) is spreading worldwide because of its very attractive properties in the fresh state as well as after hardening as of if its more and more advantages and applications.

A) Define:

"Self-Compacting Concrete (SCC) is concrete which flows under its own weight without any segregation and maintaining its homogeneity, also flows through all shapes and obstructions and needing no vibrations for compaction (self compacting)."
Thus the main requirements of SCC are flowability, filling ability, self-compacting without segregation i.e maintaining homogeneity.
The above can be achieved by proper mix design, which can be more appropriately stated as proportioning of various components of concrete.To achieve a highly mobile concrete , a low yield stress is required and for a high resistance to segregation a highly viscous material is required. Addition of water decreases the yield stress but lower the viscosity. Addition of superplasticiser also lowers the yield stress but will decrease the yield stress slightly. On the other hand, viscosity of a mix can be improved by changes in mix constituents or by adding a viscosity modifier cut this will increase the yield stress of the paste. Thus a balance between the two requirements needs to be implemented.

B) Need of Self-Compacting Concrete (SCC)

- faster construction
- reduction in site manpower
- better surface finishes
- easier placing
- improved durability
- greater freedom in design thinner concrete sections
- reduced noise levels, absence of vibration
- Safer working environment.

I. CONCRETE MATERIALS

A) Binder

The function of the binder in concrete is to chemically bind all the constituent materials to form a stone like material. The commonly used binders in concrete are cement, fly ash (FA) and (or) fiber.

B) Aggregates

The aggregate properties that are most important with regard to self-compacting concrete are: Particle shape, particle size distribution, mechanical properties of the aggregate particles, and possible chemical reactions between the aggregate and the paste which may affect the bond. Unlike their use in ordinary concrete, where we rarely consider the strength of the aggregates, in high performance concrete the aggregates may well become the strength limiting factor. Also, since it is necessary to maintain a low w/c ratio to achieve high strength, the aggregate grading must be very tightly controlled.

C)Superplasticizers

In modern concrete practice, it is essentially impossible to make high performance concrete at adequate workability in the field without the use of Superplasticizers. Unfortunately, different Superplasticizers will behave quite differently with different cements (even cements of nominally the same type). This is due in part to the variability in the minor components of the cement (which are not generally specified), and in part to the fact that the acceptance standards for Superplasticizers themselves are not very tightly written. Thus, some cement will simply be found to be incompatible with certain Superplasticizers.

There are, basically, three principal types of superplactisizer: (I) ligno-sulfonate-based; (ii) polycondensate of formaldehyde and melamine sulfonate (often referred to simply as melamine sulfonate); and (iii) polycondensate of formaldehyde and naphthalene sulfonate (often referred to as naphthalene sulfonate).

There is no a prior way of determining the required superplactisizer dosage; it must be determined, in the end, by some short of trial and error procedure such as Marsh cone test. Basically, if strength is the primary criterion, then one should work with the lowest w/c ratio possible, and thus the highest superplactisizer dosage rate. However, if the rheological properties of the high strength concrete are very important, then the highest w/c consistent with the required strength should be used, with the superplactisizer dosage then adjusted to get the desired workability. In general, of course, some intermediate position must be found, so that the combination of strength and rheological properties can be optimized.

II. METHODOLOGY AND TESTS OF MIX DESIGN

A) INTRODUCTION:

To obtain accurate results, it is important that the mixing and testing procedures are as identical as possible throughout the project. This includes: same equipment, procedures, laboratory environment and materials.

In this chapter, the mixing procedures, test methods for the fresh paste, mortar and concrete and hardened concrete are described and methods of data evaluation are demonstrated. All materials were stored in the laboratory at ambient temperature before use, and mixing and testing were carried out at room temperature which varied from 18 to 28 °C, but was normally between 18 and 23°C.

SCC can be designed to fulfill the requirements of Indian standard regarding density, strength development, final, strength and durability. Due to high content of powder, SCC may show more shrinkage or creep than ordinary concrete mixes. Special care should also be taken to begin curing the concrete as early as possible.

FINDINGS OF AGGREGATE

AGGREGATES-(FINE, COARSE (FRECTION I & II) (Ref. Standard:IS 2386)

Sr. No	Test Name	Unit	Fine Aggregate Sand	Coarse Aggregate Fraction - I 20 mm	Coarse Aggregate Fraction - II 10 mm
1	Silt Content	%	0.98	NA	NA
2	Specific Gravity	---	2.6	2.83	2.80
3	Bulk Density	Kg/m³	1565	1465	1499
4	Water Absorption	%	1.1	0.92	1.12
5	Free Surface Moisture	%	0	0	0

FINDINGS OF ADMIXTURE

Sr. No	Test Name	Unit	Chemical Admixture	Mineral Admixture
1	Specific Gravity	---	1.1	2.1
2	Bulk Density	Kg/m³	1100	1200
3	Dry Material Content	%	-	-
4	Admixture to be used	%	1.4	

Gradation For Fine Aggregate (Sand):			ZONE-I			
			Material Taken for Sieveing =>	2000		
Sr. No	Sieve Size	Unit	Retained Material in gm	Retained %	Cummulative Retained %	% Passing
1	10mm	gms	0	0	0	100.0
2	4.75mm	gms	80	4	4	96.0
3	2.36mm	gms	114	5.7	9.7	90.3
4	1.18mm	gms	478	23.9	33.6	66.4
5	600mic	gms	770	38.5	72.1	27.9
6	300mic	gms	397	19.85	91.95	8.1
7	150mic	gms	132	6.6	98.55	1.5
8	75mic	gms	14	0.7	99.25	0.8
			1985			

Gradation For Coarse aggregate Aggregate:						
Material Taken for sieving	Unit	FRACTION I:		FRACTION II:		GRADED AGGREGATES
		20 mm		10 mm		
Proportion		5000		5000		
		60%		40%		
Size of aggregate		Retained	% Passing	Retained	% Passing	
80 mm	gms	0	100.00	0	100.00	100.00
40 mm	gms	0	100.00	0	100.00	100.00
25 mm	gms	0	100.00	0	100.00	100.00
20 mm	gms	909	81.82	0	100.00	89.09
16 mm	gms	1465	52.52	0	100.00	71.51
12.5 mm	gms	1782	16.88	0	100.00	50.13
10 mm	gms	710	2.68	22	99.56	41.43
6.3 mm	gms	126	0.16	1743	64.70	25.98
4.75 mm	gms	0	0.16	1128	42.14	16.95
2.36 mm	gms	0	0.16	2099	0.16	0.16
		4992		4992		

FINDINGS OF CEMENT			
CEMENT (Reference Standard : IS 4031)			
Sr. No.	Test Name	Unit	RESULT
1	Consistency	%	30.0
2	Initial Setting Time	Minutes	90
3	Final Setting Time	Minutes	240
4	Soundness By Le Chatlier Method	mm	2.00

B) Mix Composition

The mix composition shall satisfy all performance criteria for the concrete inn both the fresh and hardened states. Indicative typical ranges of proportions and quantities in order to obtain self-compactability are given below.

- Water/powder ratio by volume of 0.8 to 1.10.
- Total powder content- 160 to 240 liters (400-600 kg) per cubic meter.
- Coarse aggregate content normally 28 to 35 % by volume of the mix.
- Water/powder ratio is selected based on requirements in EN 206. Typically water content does not exceed 200 litre/m^3.
- The sand content balances the volume of the other constituents.

Generally it is advisable to design conservatively to ensure that the concrete is capable of maintaining its specified fresh properties despite anticipated variations in raw material quality. Some variation in aggregate moisture content should also be expected and allowed for at mix design stage. Normally viscosity modifying admixture are a useful tool for compensating for the fluctuations due to any variations of the sand grading and the moisture content of the aggregates.

As per criteria:

Sr. No	Description	Requirement	As Per Design	Remarks
1	Water/powder ratio by volume	0.8 to 1.10	0.98	Comply
2	Total powder content	400 to 600 kg/m^3	540	Comply
3	Coarse aggregate content by volume of the mix	28 to 35 %	30.3%	Comply
4	Water/cement	-	0.37	Comply
5	Water content	Max. 200 kg/m^3	198.0 kg/m^3	Comply
6	Sand content by volume of mortar	-	56.4%	-

c) Test methods

Many different test methods have been developed in attempts to characterize the properties of SCC. SO far no single method or combination of methods has achieved universal approval and most of them have their adherents. Similarly no single method has been found which characterizes all the relevant workability aspects so each mix design should be tested by more than one test method for the different workability parameters.

List of test methods for workability properties of SSC

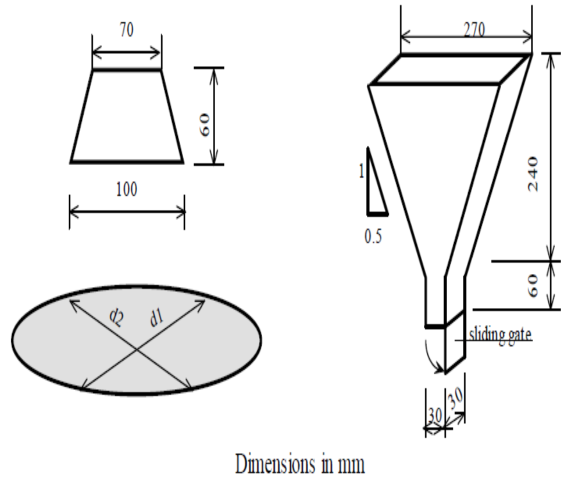
	Methods	Property
1	Slump-flow by Abrams cone	Filing ability
2	T_{50cm} Slumpflow	Filing ability
3	J-ring	Passing ability
4	V-funnel	Filing ability
5	V-funnel at T5minutes	Segregation resistance
6	L-box	Passing ability
7	U-box	Passing ability
8	Fill-box	Passing ability

For the initial mix design of SSC all three workability parameters need to be assessed to ensure that all aspects are fulfilled. For site quality control, two test methods are generally sufficient to monitor production quality. Typical combinations are Slump-flow and V-funnel or Slump-flow

D) TESTS

1) SPREAD AND V-FUNNEL TEST

The apparatus for the spread test (shown in Fig) comprises a frustum cone and a glass plate. All surfaces of the cone and glass plate were clean and just-moist at the start of each test.
The cone was placed on the centre of glass plate, filled with the sample without compaction and then lifted vertically. After the sample stopped flowing, the diameters of the deformed sample in two perpendicular directions were measured as d1, d2 (mm).

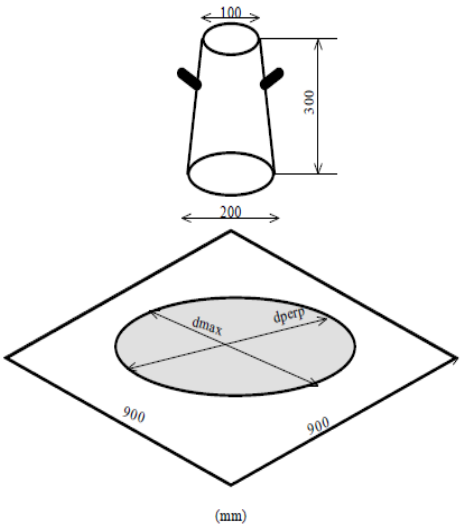


(a) Spread test (b) V-funnel test

The final spread was the average of d1 and d2 (mm). If a spread with a 'halo' of mortar, the thickness of the halo was measured. The V-funnel test, which is used to assess deformability rate of SCC flowing through a restricted area.The surface of the V-funnel was clean and just-moist before the first test and was not cleaned between repeat tests. The V-funnel was placed horizontally with the gate closed and was filled with mortar without tamping. Then the gate at the bottom of the orifice was opened to let concrete flow out under gravity and started to time. The time of the first light seen from the top was recorded. The above operation was carried out three times using the same sample. The surface of V-funnel was saturated with mortar after the first flow. The first reading was discarded and the V-funnel time taken as the average of second and third recording. To assess the consistence retention, spread and V-funnel time were measured at 30, 60 and 90 minutes after first adding the water to the mix. Between measurements, the mortar was stored in the mixing bowl and covered with a damp cloth to avoid moisture loss. The mortar was remixed before each test for 30 seconds.

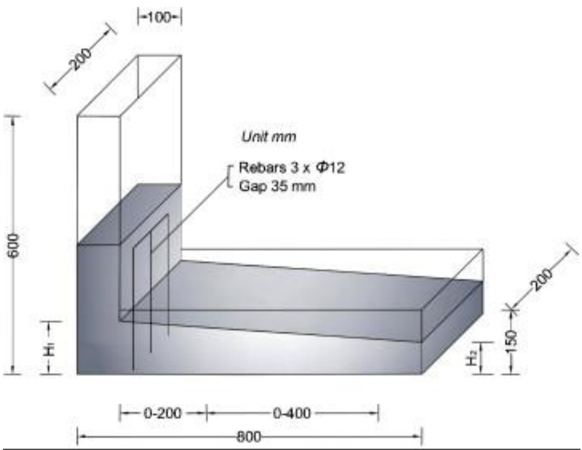
2) SLUMP FLOW TEST

Slump flow test was carried out in accordance with EN 12350-8 (2007), from which slump flow and T500 were obtained, assessing deformation ability and deformation rate in the absence of obstructions respectively. The dimensions of mould and base plate are shown in Figure 4-5. The surfaces of all the apparatus were clean and damp before each test. The mould was placed in the centre of the plate and filled with about 6 litres concrete without external compaction. The mould was lifted vertically and the concrete was allowed to flow out freely. The test ended when concrete stopped flowing. Slump flow was the mean diameter of the concrete at two perpendicular directions S=(dmax+dperp)/2 and expressed to the nearest 5 mm. T500 was the time from lifting the cone to the concrete reaching a diameter of 500 mm. It was measured at the initial stage of this project but not tested later for the following reasons: In testing, it is difficult to lift the mould and start the stopwatch for measuring T500 time at the same time for a single operator. The time for the concrete to reach the 500 mm circle is difficult to assess reliably.



3) L-BOX TEST

The L-box test was used to assess the passing ability of SCC at the initial stage of designing SCC. The dimensions of the three-bar L-box used are shown in Figure.

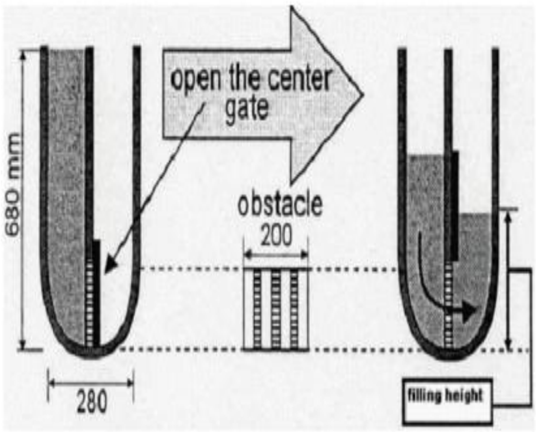


The vertical part of the box is filled with about 12 litres of concrete without tamping and left to rest for one minute in order to allow any segregation to occur. Then the sliding gate is lifted and the concrete flows out of the vertical part into the horizontal part through the reinforcement bars. The times for the front concrete to reach a distance of 200 mm along the horizontal part, and the

heights of concrete at the two ends of the box are measured, H1 and H2, after the concrete has stopped flowing, were measured in three places each and the average taken. The ratio of H2/H1, called the blocking ratio (BR), is used to evaluate the passing ability. If coarse aggregates are evenly distributed on the concrete surface or there are no aggregate particles wedged between the bars, the mix can be regarded as having no segregation.

4) U-BOX TEST

This test is used to assess the passability of SCC.
The equipment is as shown in the figure. This equipment has a 'U' shape and an opening with a sliding gate is fixed between the two compartments with vertical steel bars as obstructions. Concrete is made to flow through the obstructions and the level difference between the top surface of concrete in both the compartments is measured.



The procedure for performing the test is as follows:

- Place the 'U' box on firm/level ground.
- Moisten the internal surface thoroughly and close the central door.
- Fill the concrete in the left compartment fully.
- Wait for a minute and lift the gate without any jerk to let the concrete flow.
- Gently wipe the slurry adhered to the face of the left compartment without disturbing the top surface of the concrete to enhance the visibility.
- Measure the difference of height between the concrete surface on either compartment. This difference will indicate the self-levelling ability and passing ability of the concrete.

Permissible range for difference h_1-h_2 is 30 mm. a difference of more than 30mm indicates possibility of blockage with viscosity being on the higher side. If h_1-h_2 is close to '0', it indicates low viscosity and concrete could easily pass through.

E) Workability criteria for the fresh SSC

Typical acceptance criteria for Self-compacting Concrete with a maximum aggregate size up to 20mm are shown as.

Sr.No.	Methods	Unit	Typical range of values	
			Minimum	Maximum
1	Slumpflow by Abrams cone	mm	650	800
2	T50cmslumpflow	sec	2	5
3	J-ring	mm	0	10
4	V-funnel	sec	6	12
5	Time increase, V-funnel at T5 minutes	sec	0	+3
6	L-box	h_2/h_1	0.8	1.0
7	U-box	$(h_2$-$h_1)$ mm	0	30
8	Fill-box	%	90	100

These typical requirements shown against each test method are based on current knowledge and practice. Values outside these ranges may be acceptable if it can demonstrate satisfactory performance in the specific condition, eg, large spaces between reinforcement, layer thickness less than 500mm, short distance of flow from point of discharge, very few obstructions to pass in the formwork, very simple design of formwork,etc.

Special care should always be taken to ensure no segregation of the mix is likely as, at present, there is not a simple and reliable test that gives information about segregation resistance of SSC in all practical situations.

Workability Criteria					
Sr.no	Method	Unit	Requirement	Results	Remarks
1	Slumpflow by Abrams cone	Mm	650 - 800	680	Comply
2	T_{50cm}slumpflow	Sec	2 - 5	3	Comply
3	V-funnel	Sec	6 - 12	11	Comply
4	L-box	(h_2/h_1)	0.8 - 1.0	1	Comply
5	U-box	$(h_2 - h_1)$ mm	Max. 30 mm	28	Comply

III. CONCLUSIONS:

From this mix design and testing methods and out come, can say that the concrete is having the following properties flow ability, filling ability, self-compacting without segregation i.e maintaining homogeneity and due to this properties I can say that it is a self compacting concrete.

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