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Investigate in quality control of fiber reinforced self-compacting concrete during construction

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Abstract. Fiber reinforced self-compacting concrete make a good combination of the benefit of flowable concrete of self-compacting concrete with the higher strength provided by the wire-like fiber reinforcement. To improve productivity and on-site working conditions, quality control is necessary to secure self-consolidating and other construction performances.

In this paper a pioneer study has been performed in quality control of fiber-reinforced self-compacting concrete other than the quality control of self-compacting concrete. Test methods and requirements are introduced. Requirements to ensure a good quality such as keeping fibers in a desired direction is also investigated.

Keywords: quality control, fiber reinforced self-compacting concrete, fiber orientation

1. Introduction

Self compacting concrete (SCC) is one kind of high performance concrete, and has been described as "the most revolutionary development in concrete construction for several decades". The main character of self compacting concrete is that there is no need of vibrating during construction process, reducing manpower demand in the construction stages of concrete structures.

SCC concrete require new technologies that allow speedy and economical construction techniques and materials with improved strength, workability and durability. Fiber reinforced self-compacting concrete (FRSCC) increases the tensile and shear strengths of concrete substantially, and reduces the size and the propagation of micro cracks. Cement-based material benefit from the addition of steel fibers.

Existing work shows that the quality control of self compacting concrete is investigated while FRSCC have something new to investigate besides the existing qualification.

2. Quality control of self-compacting concrete

There are some characteristics to evaluate self-compacting concrete.

- High flowability:

High flowability ensures that SCC can overcome inner resistance (including viscous force of gelled material and friction between particles) and adhesive force with the formwork and reinforcing steel bar, so that the concrete can flow and fill the formwork. The level of fluidity of the SCC is mainly governed the dosing of superplasticizer, however, overdosing may lead to the risk of segregation and blockage.

- High stability

High stability ensures that SCC can reach a uniform quality to remain homogeneous in composition during transport and placing.

- Passing ability :

This ensures that no blocking happens when concrete pass through the steel bars.

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Segregation resistance: this is a synthetic indicator of high flowability, high stability and ability to pass the gap between the steel bars.

2.1. Test methods

To ensure a sound quality of self-compacting concrete, a series tests should be carried out, test methods of the SCC concrete are listed below

Character	Field test	Measuring unit	Range of values	
			Minimum	maximum
Flowability	Slump flow	mm	650	800
	T_{50} slump flow	sec	2(3)	5(7)
	V-funnel	sec	6	12
	Orimet	sec	0	5
Passing ability	J-ring	mm	0	10
Segregation resistance	GTM-test	%	0	15
	V-funnel at T_{5min}	sec	0	+3

Table1.test methods of the SCC concrete

- Slump flow test

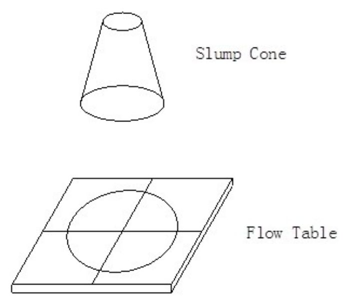

Fig. 1: slump flow test

This test is to assess the horizontal flow ability of the concrete, and the diameter of the concrete circle is a measure for the filling ability of the concrete.

Method: place base plate on level stable ground and the slump cone centrally on the base plate. fill the cone with the scoop, raise the cone vertically and allow the concrete to flow out freely. At the same time, start the stopwatch and record the time from the very beginning to reach the 500mm spread circle(T50).

Measure the average of the two measured diameter(slump flow in mm).

- V-funnel test

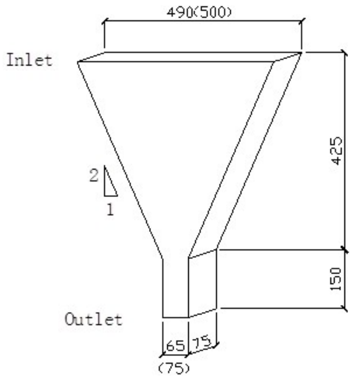

Fig. 2: V-funnel test

Set the V-funnel on firm ground, keep the trap door open to allow surplus water to drain, close the trap door and place a bucket underneath, then open the door and allow the concrete to flow out under gravity. Measure the time between the door is opened and the discharge to complete (the flow time s).

Fill the funnel with the concrete again, open the trap door 5 minutes after the second fill and allow the concrete to flow out under gravity. Simultaneously start the stopwatch(the flow time at t=5min).

- J-ring test

Place the J-ring centrally on the base plate and the slump cone centrally. Fill the cone and remove any surplus concrete from around the base of the cone. Raise the cone vertically and allow the concrete to flow out freely.

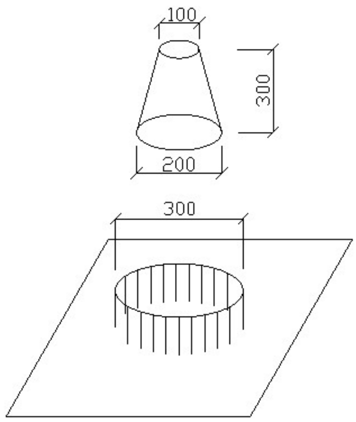

Fig. 3: J-ring test

Calculate the average of the two measured diameters(in mm).

Measure the height of different places inside and outside the bars, then calculate the average of the difference value of the height(in mm)

- GTM screen stability test method

Put the concrete in the bucket and keep it for 15 minutes covered with a lid to prevent evaporation. Inspect the surface of the concrete if there is any bleeding water. Pour the top 2 litre concrete sample into pouring container, pour all the concrete from the pouring container onto the sieve from a height of 500mm in one smooth continuous movement

Calculate the percentage of sample passing sieve (M_b/M_a)

M_b mass of sample passing sieve

M_a mass of concrete poured onto the sieve.

As to transportation, there should be some measure to maintain the workability to meet the requirement of construction. It is essential to make sure that delivery and placing can be completed within the workability-retention time of the concrete.

There is little or no bleed water at the surface, so SCC tends to dry faster than vibrated concrete, initial curing is commended to take as soon as possible after placing in order to minimize the risk of shrinkage cracking.

3. Special quality control of FRSCC

Besides the qualification mentioned above for SCC quality control, additional requirement should be placed as fiber dispersion and orientation are crucial for the structural performance and have to be effectively checked at the production stage for a sound quality.

Lab experiment and numerical simulation using CFD (Computational Fluid Dynamics) method had been done to investigate the flow behavior and fiber orientation of fiber reinforced Self compacting Concrete.

Mixture component	**Cement**	**FCC**	**Admixture**	**Fine sand**	**Coarse sand**	**W/B(binder)**
Type	42.5R/SR		Viscosity agent	0-0.6mm	4-16mm	
Content(kg/m^3)	1000	150	34.5	329.5	769	0.18(no unit)

Table2.mixing proportion of the tested concrete

3.1. Relationship between fiber orientation and the pouring direction

Experiments show that pouring the concrete as 1 (follow one certain direction) shows have a better fiber orientation than 2 (back and forth along the beam), which can be seen in the bending moment curve. In construction process it is advised to cast the specimen following a direction paralleled to the direction of preferred fiber orientation.

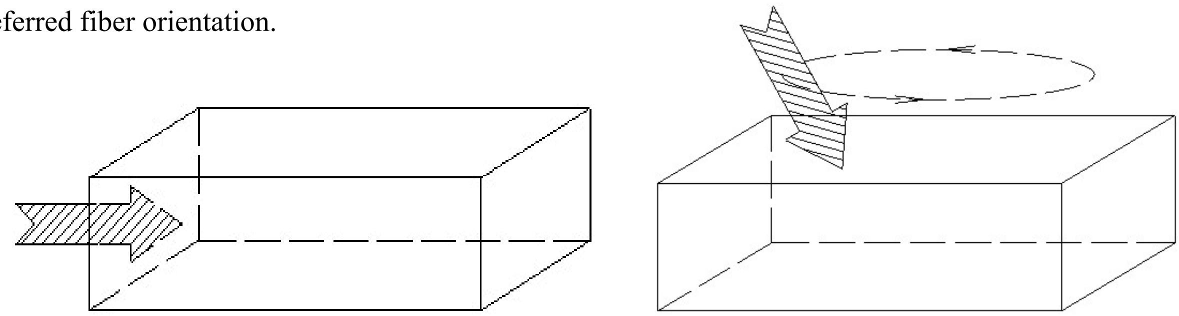

Fig. 4:different pouring direction

3.2. Relationship between fiber orientation and the pouring position

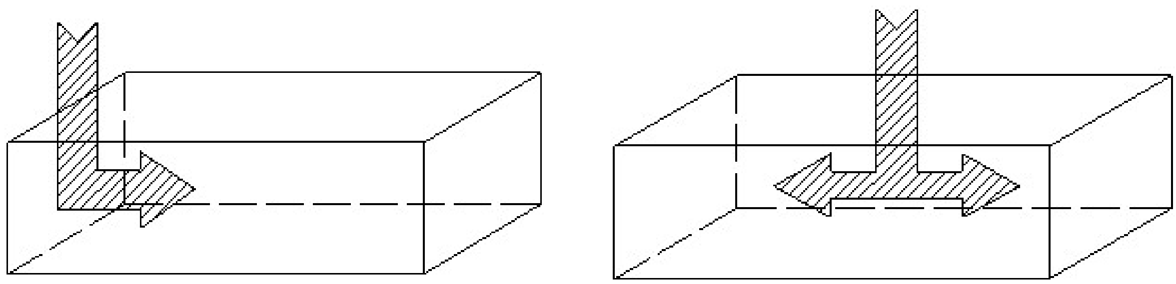

Fig.5:different pouring position

It has also been found that pouring the concrete through one side of beam show a better fiber orientation than pouring at the middle of the beam, it can be inferred that a certain flow distance should be allowed to achieve a sound quality of fiber orientation.

3.3. Relationship between fiber orientation and the pouring speed

Attempts have been made to investigate the relationship between the pouring speed and the fiber orientation. To make the results more direct, we perform this work using CFD method. It can be seen with the increasing pouring speed, not only back flow occurred, but the fibers also show an unsatisfying, but the speed should not be too small to prevent segregate.

Nowadays, no equipment or method can be used to detect fiber orientation in-site, there is a requirement that we should take some measure during construction process to ensure a good orientation.

4. Conclusion

FRSCC is a kind of newly developed concrete, to reach a good quality we need not only to meet the demand of quality control of SCC but also fulfill the requirement of a good fiber orientation. Experiments and simulation show that the quality of fiber orientation has relation with pouring direction, pouring position and pouring speed, overall consideration should be made before construction.

5. References

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