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Understanding the Self Compacting Concrete & Its Fresh Properties

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Abstract

A new kind of high performance concrete (HPC) i.e. self compacting concrete has been first developed in Japan in 1986. The development of SCC has made casting of dense reinforcement and mass concrete convenient, has minimized noise. Fresh self-compacting concrete (SCC) flows into formwork and around obstructions under its own weight to fill it completely and self-compact (without any need for vibration), without any segregation and blocking. The elimination of the need for compaction leads to better quality concrete and substantial improvement of working conditions. SCC mixes generally have a much higher content of fine fillers, including cement, and produce excessively high compressive strength concrete, which restricts its field of application to special concrete only. To use SCC mixes in general concrete construction practice, requires low cost materials to make inexpensive concrete. This paper highlights information about the SCC and its characteristics in fresh state.

Keywords:Self Compacting Concrete.

Introduction

It was against this background that self-compacting concrete (SCC), which eliminates the Need for compaction, has been developed and its advantages exploited. Pioneering studies in Japan in late 1980s was followed by several spectacular uses; the technology then spread rapidly to many other in countries in Asia and Europe and more recently to North America (where the alternative name self-consolidating concrete is used). In Europe, a major project carried out by a consortium of eight partners between 1997 and 2000 demonstrated that environmentally-friendly SCC could be produced and used, with benefits to the construction process, to workers, and to people living near construction sites.
The concept of self compacting concrete was proposed in 1986 by Professor Hajime Okamura but the prototype was first developed in 1988 in Japan, by Professor Ozawa (1989) at the University of Tokyo. The development of Self-Compacting Concrete (SCC), also referred to as ‘‘Self Consolidating Concrete’’, “Self Leveling Concrete” and ‘‘High-Performance Concrete’’, has been described as "the most revolutionary development in concrete construction for several decades". The introduction of the SCC is associated with the drive towards better quality of concrete pursued in Japan in late 1980’s, where the lack of uniform and complete compaction had been identified as the primary factor responsible for poor performance of concrete structures.[1]

SCC is an innovative concrete that does not requires 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 the same mechanical properties and durability as traditional vibrated concrete. [2] Originally developed to offset a growing shortage of skilled labour, it has proved beneficial economically because of a number of factors, including:

· 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 [3]

Such concrete should have a relatively low yield value to ensure high flow ability, a moderate viscosity to resist segregation and bleeding, and must maintain its homogeneity during transportation, placing and curing to ensure adequate structural performance and long term durability. The successful development of SCC

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must ensure a good balance between deformability and stability. [4]

Advantages of SCC

- Not require external vibration for placing and compaction.
- It is able to flow under its own weight, completely filling form work and achieving full compaction, even in the presence of congested reinforcement.
- The hardened concrete is dense, homogeneous and has the same engineering properties as conventional concrete.
- Fluidity and segregation resistance of SCC ensures a high level of homogeneity, minimal concrete voids and uniform concrete strength, providing the potential for a superior level of finish to the structure.
- The elimination of vibrating equipment improves the environment on and near construction sites where concrete is being placed, reducing the exposure of workers to noise and vibration.

Materials for SCC

Mixture proportions for SCC differ from those of ordinary concrete, in that the former has more powder content and less coarse aggregate. Moreover, SCC incorporates high range water reducers (HRWR, superplasticisers) in larger amounts and frequently a viscosity modifying agent (VMA) in small doses.

1) Aggregates: Aggregates constitute the bulk of a concrete mixture, and give dimensional stability to concrete. Among the various properties of aggregate, the important ones for SCC are the shape and gradation. It is observed from the studies that self-compactability is achievable at lower cement (or fines) content when rounded aggregates are used, as compared to angular aggregates. [5]
2) Admixtures: SCC invariably incorporates chemical admixtures - in particular, a high range water reducers (HRWR) and sometimes, viscosity-modifying agent (VMA). The HRWR helps in achieving excellent flow at low water contents and VMA reduces bleeding and improves the stability of the concrete mixture. An effective VMA can also bring down the powder requirement and still give the required stability. Moreover, SCC almost always includes a mineral admixture, to enhance the deformability and stability of concrete. [6]
3) Filler: Flyash, Silica fumes, GGBS, Metakaolin: Improve the quality, durability, workability and mechanical properties.
4) Mixing water: Same as RCC or prestressed concrete (potable or recycled water can be used.

Figures 1, 2, 3 and 4 shows different advantages and properties on fresh SCC.

Fig. 1 Flow of SCC

Fig. 2 Pouring of SCC in congested reinforcement

Fig. 3 Pouring of SCC by pumping

Fig. 4 Finishing surface of SCC

Reasons for Increasing Demand of SCC

- Complex shape of concrete structures and densely arranged bars

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make it more difficult to use a vibrator.

- Vibratory compaction is noisy and deleterious to the health of construction workers, as well as an annoyance to people in the neighborhood.
- In remote areas it is difficult to find skilled workers to carry out the compacting work at construction sites.

Fig. 5 shows necessity of self compacting concrete.

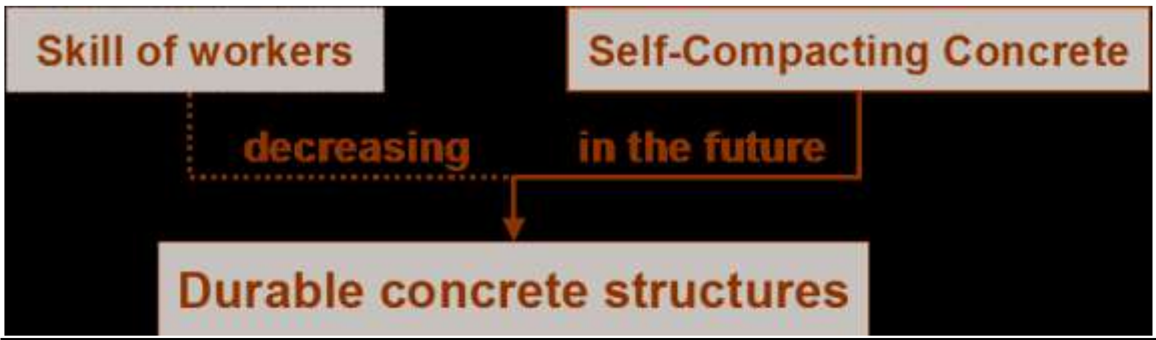

Fig. 5 Necessity of SCC

Mix design principles

The following Mix Design Principles result in concrete that, compared to traditional vibrated concrete , normally contains:

- Lower Coarse aggregate content
- Increased Paste Content
- Low water/powder ratio
- Increased Superplasticizer
- Sometimes a viscosity modifying agent

Fig.6 shows comparison of Normal strength and Self compacted Concrete with respect to mix design.

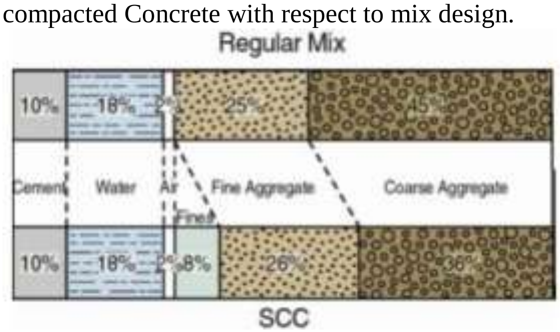

Fig. 6 comparison of NSC and SCC by Volume

Fresh Property Tests of Self Compacting Concrete

1. **Slump flow test and T50cm test:** The slump flow test shown in Fig.7 and 8 is used assess the horizontal free flow of in the absence of obstructions. The test method is based on the test method for determining the slump .T diameter of the concrete circle is a measure for the filling ability of the concrete. This is a simple, rapid test procedure, though two people are needed if the T50 time is to be measured. It can be used on site, though the size of the base plate is somewhat unwieldy and level ground is essential. It is the most commonly used test, and gives a good assessment of filling ability. It gives no indication of the ability of the concrete to pass between reinforcement without booking, but may give some indication of resistance to segregation.
2. **V funnel test:** The equipment consists of a v shaped funnel as, show in Fig.10. An alternative type of V-funnel, the O funnel, with circular. The described V-funnel test is used to determine the filling ability (flow ability) of the concrete with a maximum aggregate size of 20mm. The funnel is filled with about 12 liter of concrete and the time taken for it to flow through the apparatus measured. After this the funnel can be refilled concrete and left for 5 minutes to settle. If the concrete shows segregation then the flow time will increases significantly.
3. **L Box Test:** This test shown in fig.11 is based on a Japanese design for under water concrete, has been described by Peterson. The test assesses the flow of the concrete and also the extent to which it is subjected to blocking by

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reinforcement. The apparatus is shown in the figure. The apparatus consist of rectangular section box in the shape of an 'L', with a vertical and horizontal section, separated by a movable gate, in front of which vertical length of reinforcement bar are fitted. The vertical section is filled with concrete, and then the gate lifted to let the concrete flow into the horizontal section. When the flow has stopped, the height of the concrete at the end of the horizontal section is expressed as a proportion of that remaining in the vertical section. It indicates the slope of the concrete when at rest. This is an indication passing ability, or the degree to which the passage of concrete through the bars is restricted. The horizontal section of the box can be marked at 200mm and 400mm from the gate and the times taken to reach these points measured. These are known as the T20 and T40 times and are an indication for the filling ability. The section of bar con be of different diameters and are spaced at different intervals, in accordance with normal reinforcement considerations, 3x the maximum aggregate size might be appropriate. The bar can principally be set at any spacing to impose a more or less severe test of the passing ability of the concrete.

U Box Test: The test shown in fig.12 was developed by the Technology Research Centre of the Taisei Corporation in Japan. Some time the apparatus is called a "box shaped" test. The test is used to measure the filing ability of self compacting concrete. The apparatus consists of a vessel that is divided by a middle wall into two compartments; an opening with a sliding gate is fitted between the two sections. Reinforcing bar with nominal diameter of 134 mm are installed at the gate with centre to centre spacing of 50 mm. this create a clear spacing of 35 mm between bars. The left hand section is filled with about 20 liter of concrete then the gate is lifted and the concrete flows upwards into the other section. The height of the concrete in both sections is measured.

Fig. 7 slump Flow Test

Fig. 8 T50 Test

Fig. 9 J ring Test

Fig. 10 V funnel Test

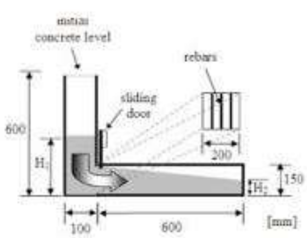

Figure 11 L Box Test

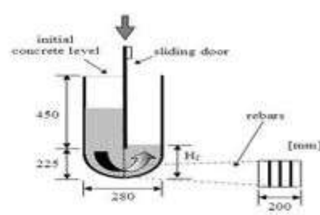

Fig. 12 U box Test

Table 1 Acceptance Criteria for Self Compacting Concrete

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Sr.No.	Methods	Properties	Unit	Typical Range	
				Minimum	Maximum
1	Slump Flow	Filing Ability	mm	650	800
2	T_{50}	Filling Ability	sec	2	5
3	J Ring	Passing Ability	mm	0	10
4	V Funnel	Segregation Resistance	sec	8	12
5	L Box	Passing Ability	h2/h1	0.8	1
6	U Box	Passing Ability	h2-h1	0	30

Conclusion

SCC Applications results in a large payoff in not requiring vibration to achieve Consolidation and the reduce noise level to meet stringent environmental requirements in urban and suburban construction sites in India. Less number of labour and fast constructions will result in substantial cost savings, less traffic disruption and risk reduction. Better durability and high strength will allow the engineers to design and build bridges to last a century and beyond.

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