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Properties of Self Compacting Concrete Containing Microsillica and Flyash

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ABSTRACT

A self-compacting concrete (SCC) is the one that can be placed in the form and can go through obstructions by its own weight and without the need of vibration. Since its first development in Japan in 1988, SCC has gained wider acceptance in Japan, Europe and USA due to its inherent distinct advantages. The major advantage of this method is that SCC technology offers the opportunity to minimize or eliminate concrete placement problems in difficult conditions. It avoids having to repeat the same kind of quality control test on concrete, which consumes both time and labour. Construction and placing becomes faster & easier. It eliminates the need for vibration & reducing the noise pollution. It improves the filling capacity of highly congested structural members. SCC provides better quality especially in the members having reinforcement congestion or decreasing the permeability and improving durability of concrete. The primary aim of this study is to explore the feasibility of using SCC by examining its basic properties and durability characteristics i.e. water absorption, shrinkage, sorptivity and sulfate resistance. An extensive literature survey was conducted to explore the present state of knowledge on the durability performance of self-consolidating concrete. However, because it usually requires a larger content of binder and chemical admixtures compared to ordinary concrete, its material cost is generally 20–50% higher, which has been a major hindrance to a wider implementation of its use. There is growing evidence that incorporating high volumes of mineral admixtures and microfillers as partial replacement for portl and cement in SCC can make it cost effective. However, the durability of such SCC needs to be proven

Keywords: SSC-Self Compacting Concrete, Silica Fume, Fly Ash

1. INTRODUCTION

Cement-based materials are the most abundant of all man-made materials and are among the most important construction materials, and it is most likely that they will continue to have the same importance in the future. However, these construction and engineering materials must meet new and higher demands. When facing issues of productivity, economy, quality and environment, they have to compete with other construction materials such as plastic, steel and wood. One direction in this evolution is towards self-compacting concrete (SCC), a modified product that, without additional compaction energy, flows and consolidates under the influence of its own weight. The use of SCC offers a more industrialised production. Not only will it reduce the unhealthy tasks for workers, it can also reduces the technical costs of in situ cast concrete constructions, due to improved casting cycle, quality, durability, surface finish and reliability of concrete structures and eliminating some of the potential for human error. However, SCC is a sensitive mix, strongly dependent on the composition and the characteristics of its constituents.

It has to possess the incompatible properties of high flow ability together with high segregation resistance. This balance is made possible by the dispersing effect of high-range water- reducing admixture (superplasticizer) combined with cohesiveness produced by a high concentration of fine particles in additional filler material. The main mechanisms controlling this fine balance are related to surface physics and chemistry hence, SCC is strongly dependent on the activity of the admixtures, as well as on the large surface area generated by the high content of fines. Fresh SCC, like all cementitious materials, is a concentrated particle suspension with a wide range of particle sizes (from 10-7 to 30 mm for concrete). The particles are affected by a complex balance of inter- particle forces (i.e. interlocking, frictional, colloidal, and electrostatic forces), generating a time dependence and visco-plastic non- Newtonian behaviour. Self-compacting concrete is considered a concrete that can be placed and compacted under its own weight without any vibration effort, assuring complete filling of formworks even when access is hindered by narrow gaps between reinforcement bars. Concrete that must not be vibrated is a challenge to the building industry. In order to achieve such behaviour, the fresh concrete must show both high fluidity and good cohesiveness at the same time

2. BACKGROUND

Self-compacting concrete (SCC) represents one of the most significant advances in concrete technology for decades. Inadequate homogeneity of the cast concrete due to poor compaction or segregation may drastically lower the performance of mature concrete in-situ.

SCC has been developed to ensure adequate compaction and facilitate placement of concrete in structures with congested reinforcement and in restricted areas. SCC was developed first in Japan in the late 1980s to be mainly used for highly congested reinforced structures in seismic regions (Bouzoubaa, Lachemi, 2001). As the durability of concrete structures became an important issue in Japan, an adequate compaction by skilled labours was required to obtain durable concrete structures. This requirement led to the development of SCC and its development was first reported in 1989 (Okamura, Ouchi, 1999).

SCC can be described as a high performance material which flows under its own weight without requiring vibrators to achieve consolidation by complete filling of formworks even when access is hindered by narrow gaps between reinforcement bars (Zhu et al., 2001). SCC can also be used in situations where it is difficult or impossible to use mechanical compaction for fresh concrete, such as underwater concreting, cast in-situ pile foundations, machine bases and columns or walls with congested reinforcement. The high flow ability of SCC makes it possible to fill the formwork without vibration. Since its inception, it has been widely used in large construction in Japan. Recently, this concrete has gained wide use in many countries for different applications and structural configurations. It can also be regarded as "the most revolutionary development in concrete construction for several decades". Originally developed to offset a growing shortage of skilled labour, it is now taken up with enthusiasm across European countries for both site and precast concrete work.

Fig. 1:

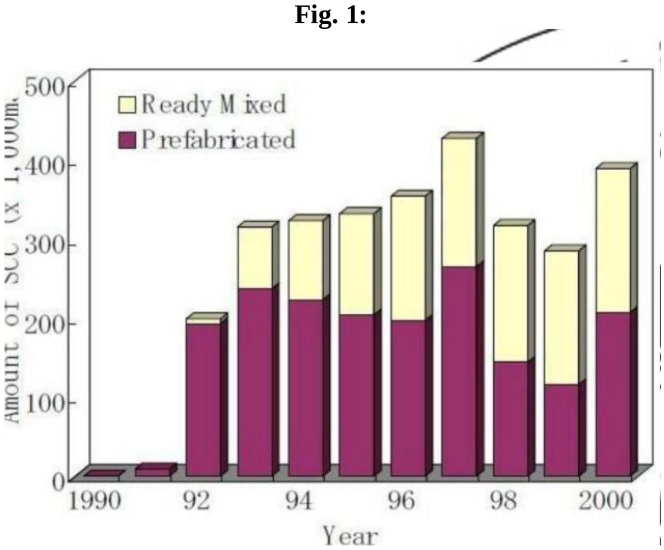

Fig: 2

3. MATERIAL USED FOR STUDY

The objective of present study is to evaluate the SSC Strength, the materials used for the research are ordinary Portland cement (OPC), microsillica, fly ash. All commonly used form materials are suitable for SCC. For surface quality of SCC, wood is better than plywood, and plywood is better than steel. More pores seem to form on the surface when the form skin is colder than the SCC.

During cold weather placement of SCC, it may be necessary to insulate the formwork to maintain temperature and normal setting time. SCC is more sensitive to temperature during the hardening process than the conventional vibrated concrete.

- Due to the cohesiveness of SCC, the formwork does not need to be tighter than that for conventional vibrated concrete.
- Higher form pressures than normal were not observed even at high rate of concrete placement. However, it is recommended that the formwork be designed for hydrostatic pressure, unless testing has shown otherwise.

4. TEST PROGRAM

U-type test: Of the many testing methods used for evaluating self-compactability, the U-type test (Fig) proposed by the Taisei group is the most appropriate, due to the small amount of concrete used, compared to others (Ferraris, 1999). In this test, the degree of compact ability can be indicated by the height that the concrete reaches after flowing through obstacles. Concrete with the filling height of over 300 mm can be judged as self-compacting. Some companies consider the concrete self- compacting if the filling height is more than 85% of the maximum height possible.

Slump Flow test: The basic equipment used is the same as for the conventional Slump test. The test method differs from the conventional one by the fact that the concrete sample placed into the mould is not rodded and when the slump cone is removed the sample collapses (Ferraris, 1999). The diameter of the spread of the sample is measured, i.e. a horizontal distance is determined as opposed to the vertical distance in the conventional Slump test. The Slump Flow test can give an Indication as to the consistency, filling ability and workability of SCC. The SCC is assumed of having a good filling ability and consistency if the diameter of the spread reaches values between 650mm to 800mm L-box test: The L-box test evaluates the passing ability of SCC in a confined space. The Lbox is composed of a vertical arm and a horizontal arm as shown in Fig . The concrete flows from the vertical arm, through reinforcing bars and into the horizontal arm of the box.

5. RESULT AND DISCUSSION

The parameters studied on the control and concrete made with replacement of fly ash and silica fume with cement in self- compacting concrete are discussed. The parameters such as Compressive strength, Water absorption, Sorptivity, Sulphate resistance are discussed and comparisons between the various mixes are represented

In order to study the effect on fresh concrete properties when fly ash is added into the concrete as cement replacement, the SCC containing different proportion of fly ash were tested for Slump flow, V-funnel, U- Box, L-box. The results of fresh properties of all Self- compacting fly ash concretes are included in Table, The Table shows the properties such as slump flow, V-funnel flow times, L-box, U- box. In terms of slump flow, all SCCs exhibited satisfactory slump flows in the range of 550–800 mm, which is an indication of a good deformability Fresh concrete properties (Fly Ash)

Table: 1

Mixture ID	Slump (mm)	V-funnel (seconds)	L-Box (H2/H1)	U-box(H1-H2)
SCC1(15% FA)	687	9	0.9	30
SCC1(15% FA)	590	13	-	-
SCC2(25% FA)	704	11	-	35
SCC2(25% FA)	740	12	0.9	35
SCC2(25% FA)	720	9	1.0	-

In order to study the effect on compressive strength when fly ash is added into self compacting concrete as cement replacement, the cube containing different proportion of fly ash were prepared and kept for curing for 7, 28 and 56 days. The test was conducted on ASTM of capacity 3000 KN. From the results (Table) it is concluded that the 56 days strength of all the mixes is invariably higher than corresponding 7 days and 28 days strength, this is due to continuous hydration of cement with concrete.

Table 2: Compressive strength of SCC mixes at various ages

MIX	Compressive Strength (N/mm^2)			Average Compressive Strength(N/mm^2)		
	7 days	28days	56 days	7 days	28 days	56 days
SCC1 (15% FA)	19	27.5	36.5	18.9	27.7	38.1
	18.4	26.9	38.7			
	19.3	28.7	39.2			
SCC2 (25% FA)	16.1	24.7	33.7	17.1	24.3	32.5
	16.7	23.6	31.4			
	18.5	24.6	32.4			
SCC3 (35% FA)	15.6	22.7	29.7	14.6	22.3	29.1
	14.6	22.9	30.0			
	13.5	21.2	27.8			
CM	20.2	28.4	36.1	20.6	28.9	33.0
	23.5	29.5	31.0			
	18	28.7	32.1			

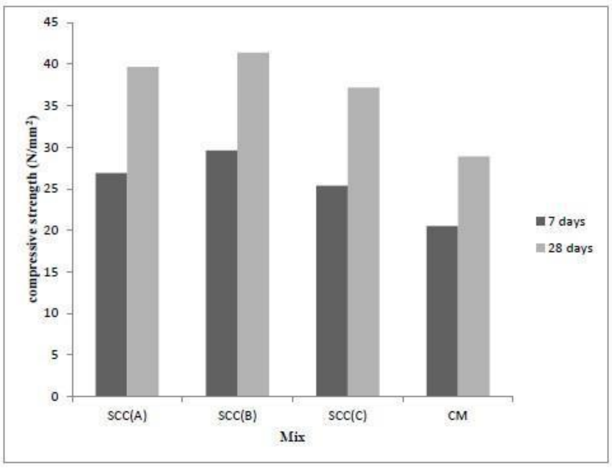

Fig.3: Compressive strength of SCC mixes at various ages with Silica fume.

CONCLUSION

The following conclusions are drawn from the present study:

1) For 35% fly ash replacement, the fresh properties observed were good as compare to 15% and 25% fly ash replacement. Hence if we increase the FA replacement we can have a better workable concrete.

2) An increase of about 24% strength at 28 days and 30% at 56 days was observed with the decrease of fly ash content from 35% FA to 15% FA.

3) Absorption is mainly influenced by the paste phase primarily; it is dependent on the extent of interconnected capillary porosity in the paste. Concrete mixes with higher paste contents are bound to have higher

absorption values than concretes with lower paste content, as observed 35% FA replacement shows higher absorption i.e. 2.67 % at the age of 28 days and 3.59 % at the age of 56 days than 15% FA replacement (0.46 % at the age of 28 days and 0.67 % at the age of 56 days).

4) 35% FA replacement shows 2 times less shrinkage in 20 days than that of 0% FA replacement. From the results it is obtained that increasing the amount of fly ash results in a systematic reduction in shrinkage.

5) Increasing the amount of fly ash results in a systematic reduction in Sorptivity, the 0% FA replacement has approximately 70 % high sorption capacity than 35% FA replacement.

6) For sulfate resistance, there is a remarkable loss in weight of 0% FA replacement (CM), as compare 35% FA replacement (SCC3). At the age of 3 days, SCC3 posses 0.600 % loss as compare to CM i.e. 2.700 %, at the age of 7 days, SCC3 losses 0.437 % as CM lost 3.130 % and by the last reading that is at the age of 21 days SCC3 lost 3.931 % and CM lost 7.410 % of weight.

Following observations have been made from the study by using Silica Fume:

1) SCCs with Silica Fume (SF) exhibited satisfactory results in workability, because of small particle size and more surface area.

2) 4 to 8 percent by mass replacement of silica fume for cement gives the highest strength for short and long terms and when silica fume is replaced by 12% the strength decreases.
3) 0% SF replacement shows higher absorption i.e. 0.206 % at the age of 28 days and 0.396 % at the age of 56 days than that of 4%, 8%, 12% i.e. 0.133 % and 0.230 % at the age of 28 and 56 days, 0.113 % and 0.150 % at the age of 28 and 56 days, 0.090 % and 0.110 % at the age of 28 and 56 days respectively, that means water absorption values of all the Self-compacting SF concretes were lower than the control mix.

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