



ENHANCE THE PROPERTIES OF DURABILITY OF SELF COMPACTING CONCRETE USING FLY ASH

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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 labor. 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. This paper investigates the study of workability and durability characteristics of Self-Compacting Concrete (SCC) with containing Class F fly ash. The process of the development of the concrete for durability aspects in various proportions varying from 0%, 10%, 15%, 20% and 25% fly ash as a replacement of cement. The main aim of the paper was to identify the best proportion of fly ash, which can be replaced with cement to get the desired durability. The effect of fly ash is evaluated by performing the different tests on the cubes and cylinders to know its durability, durability tests (compressive strength of cubes after cured in sodium chloride and sulphuric acid for 56 days). Tests of these specimens were conducted at 7, 28 and 56 days after casting.

Keywords-Durability; Fly Ash, Self-Compacting Concrete, Workability Test.

I. INTRODUCTION

Self Compacting Concrete (SCC) was developed in Japan in the late 1980's. It is the concrete which is fully compacted without segregation without external energy. SCC has economic, social and environmental benefits over conventionally vibrated concrete. SCC is made from the same basic constituents as conventional concrete but with the addition of a viscosity modifying admixture and high range water reducing super plasticizing admixtures to impart high workability. The cement (powder) content of SCC is relatively high. The ratio of fine to coarse aggregates is more in Self Compacting Concrete. Fine fillers such as fly ash, silica fume, slag, Metakaolin, marble dust and rice husk ash may be used in cement to increase the paste content.

Self Compacting Concrete is a new class of high performance concrete used to facilitate and accelerate concrete placement without mitigating in-situ properties and durability. The problem of casting concrete in heavily reinforced sections has been a major topic of interest in construction. Proper consolidation and placement of concrete in such heavy reinforced sections require adequate compaction by internal or external mechanical vibrators operated by skilled workers. However, when passing through narrow areas, excessive vibration can lead to segregation, bleeding and blockage of concrete particles. The use of Self Compacting Concrete (SCC) is one way to reduce the intensive labour demand for vibration and alleviate the problems arising from bleeding and segregation. SCC is a high flow concrete, it is usually poured from one side of the formwork and spreads under its own weight, filling all spaces and corners until it reaches the other side and levels itself without segregation, and without the use of vibrators for consolidation.

Fly ash is an industrial by-product, generated after the combustion of coal in the thermal power plants. The increasing scarcity of raw materials and the urgent need to protect the environment against pollution has accentuated the significance of developing new building materials based on industrial waste generated from coal fired thermal power stations creating unmanageable disposal problems due to their potential to pollute the environment. Fly ash, when used as a mineral admixture in concrete, improves its strength and durability characteristics. Fly ash can be used either as an admixture or as a partial replacement of cement. It can also be used as a partial replacement of fine aggregates, as a total replacement of fine aggregates and as supplementary addition to achieve different properties of concrete (Jino et al., 2012). Viscosity Modifying Admixtures (VMA) make the concrete more tolerant to variations in the water content of the mix, so that plastic viscosity is maintained and segregation is prevented (EFNARC, 2005).

II. MATERIALS USED IN PRESENT STUDY

2.1. Fly Ash

Fly-ash also known as 'Pulverized Fuel Ash' is one of the coal combustion produce, compost of the fine particles that are driven out of the boiler with the flue gases. Ash that falls in the bottom of the boiler is called bottom ash. In modern coal fired power plants, fly-ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys. Together with bottom ash removed from the bottom of the boiler. It is known as coal ash. Fly-ash can significantly improve the workability of concrete. Recently, techniques have been developed to replace particles in it with high volume fly-ash.

2.2. Self Compacting Concrete

Self-compacting concrete (SCC) is a flowing concrete mixture that is able to consolidate under its own weight. The highly fluid nature of SCC makes it suitable for placing in difficult conditions and in section with congested reinforcement. Use of SCC can also help minimize hearing-related damages on the worksite that are induced by vibration of concrete. Another advantage of SCC is that the time required to place large sections is considerably reduced.

When the construction industry in Japan experienced a decline in the availability of skilled labor in the 1980s, a need was felt for a concrete that could overcome the problems of defective workmanship. This led to the development of self-compacting concrete, primarily through the work by Okamura. A committee was formed to study the properties of self-compacting concrete, including a fundamental investigation on workability of concrete, which was carried out by Ozawa et al. at the University of Tokyo. The first usable version of selfcompacting concrete was completed in 1988 and was named "High Performance Concrete", and later proposed as "Self-Compacting High Performance Concrete".

Current studies in SCC, which are being conducted in many countries, can be divided into the following categories:

- Use of rheometers to obtain data about flow behavior of cement paste and concrete,
- Mixture proportioning methods for SCC,
- Characterization of SCC using laboratory test methods,
- Durability and hardened properties of SCC and their comparison with normal concrete, and
- Construction issues related to SCC.

III. TEST PROGRAM AND PROCEDURE

The process of the development of the concrete for strength aspects in various proportions varying from 0%, 10%, 15%, 20% and 25% fly ash as a replacement of cement. The main aim of the study was to identify the best proportion of fly ash, which can be replaced with cement to get the desired strength. The effect of fly ash is evaluated by performing the different tests on the cubes and cylinders to know its compressive strength at different intervals of days, splitting tensile strength. Tests of these specimens were conducted at 7, 28 and 56 days after casting.

3.1. Workability Test

3.1.1 V-Funnel Test

A V-funnel made to the dimensions (tolerance ± 1 mm) as shown in the fig., fitted with a quick release watertight gate at its base and supported in such a way that the top of the funnel is horizontal. The V-funnel apparatus shall be made of metal and the surfaces of the metal be smooth, and not be such that it is not readily attacked by cement paste or be susceptible to rusting.

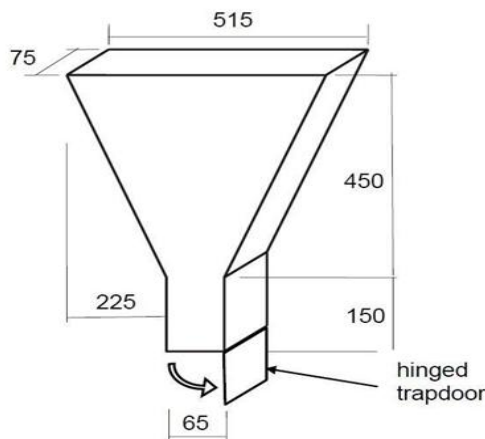


Figure 1 V-Funnel test Apparatus

3.1.2 L-Box Test

L-box, having the general arrangement as shown in fig. and the dimensions (tolerance ± 1 mm) are as shown in the fig. The L-box might be of inflexible construction with surfaces that are smooth, level and not promptly assaulted by cement paste or be at risk to rusting. The vertical hopper might be removable for simplicity of cleaning. With the entryway shut, the volume of the vertical hopper should be (12, 6 – 12, 8) l when filled level with the best.

The assemblies holding the reinforcement bars shall have 2 smooth bars of 12 mm diameter with a gap of 59 mm for the two bar test and 3 smooth bars of 12 mm diameter with a gap of 41 mm for the three bar test. These assemblies shall be interchangeable and locate the bars in the L -box so that they are vertical and equidistant across the width of the box.

The principles of the L- shaped box are shown in figure. With the L-shaped box, it is possible to measure different properties, such as flowability, blocking and segregation. The vertical part of the box, with the extra adapter mounted, is filled with concrete. After the concrete has rested in the vertical part for one minute, the sliding gate is lifted. The concrete will now flow out of the vertical part into the horizontal part of the L-box. On its way, it has to pass the layer of reinforcement. After the sliding gate is removed, the time for the concrete front to reach marking is recorded. When the concrete has stopped; the distances H_1 and H_2 are measured.

Acceptable values of the so-called blocking ratio, H_2/H_1 , can be 0.80 – 1.0. Both blocking and stability can be detected visually. If the concrete builds a plateau behind the reinforcement layer, the concrete has either blocked or segregated. Blocking usually displays itself by coarse aggregates gathered between the reinforcement bars. If coarser aggregates are distributed on the concrete surface all the way to the end of the horizontal part, the concrete can be regarded as stable.

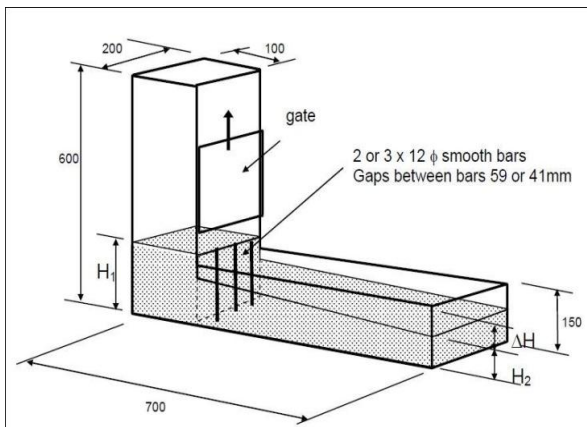


Figure 2 L-Box test Apparatus

3.1.3 Slump-Flow Test

Slump-flow tests are used to determine flowability and stability of SCC. The equipment consists of one slump cone and one flow table. A concentric diameter of 500 mm is marked on the table. The slump cone is filled with concrete while pressing the slump cone to the table. Next, the slump cone is lifted vertically and time measurement is started. Time for the concrete diameter to reach 500 mm is recorded. When the concrete has stopped flowing, the final diameter of the concrete and if necessary any segregation border at the concrete periphery is measured.



Figure 3 Slump Flow Test

3.2 Durability Test

3.2.1 Salt Ponding Test

Chloride attack is particularly important because it primarily causes corrosion of reinforcement; statistics have indicated that over 40 percent of failure of structures is due to corrosion of reinforcement. To evaluate the chloride resistance of concrete and mortar Salt Ponding Test has been used. It involves the ponding of salt solution on concrete cube specimens. After curing of specimen for 28 days in water, the specimens were submerged into 2.5% NaCl solution in a tank up to 56 days. Every 2 weeks the chloride solution was renewed by same chloride solution.

After 56 days the specimens were removed from the tank and weighted and tested for compressive strength in CTM Machine.



Figure 4 Salt Ponding Test

3.2.2 Acid ponding Test

The effect of different exposure condition will be different on concrete. To study the effect of exposure to acidic environment, specimens were immersed in 2.5% of solution of Sulphuric Acid (H_2SO_4), after curing for 28 days in normal water, up to 56 days. The acidic solution is refreshed after 8 weeks with the same solution.

After 56 days the specimen removed from tank and weighted and tested for compressive strength in CTM machine.



Figure 5 Acid Ponding Test

IV. RESULTS AND DISCUSSION

4.1 Workability Test Results

The results of V-Funnel test for different percentage of ground granulated blast-furnace slag and marble dust as a replacement of cement are shown in table below. Based on the results from V Funnel test it can be observed that, filling ability of the self compacting concrete with replacements by fly ash and marble dust are consistence with the result for control mix.

Table 1 Workability Test Result

Sr. No	Mix ID	V-Funnel (S)	L-Box	Slump Flow (mm)
1	F-0	6	0.9	625
2	F-10	6.5	0.905	650
3	F-15	7	1	650
4	F-20	7.5	0.8	650
5	F-25	8	0.7	645

Based on the results from V Funnel test it can be observed that, filling ability of the self compacting concrete with replacements by fly ash is consistence with the result for control mix.

Above test results for L Box test represent that passing ability of the self compacting concrete for different mixes depends on the fly ash contents. Results shows that passing ability of the SCC increases up to replacement of cement by 15 % fly ash, further increase in fly ash content passing ability of SCC starts to reduce mainly because of the lumps formed in the SCC mix.

Based on the above test results, it can be observed that Slump flow in case of self compacting concrete increases effectively from 625 mm to 650 mm for control mix and F-15 respectively, further increase in content reduces the slump flow of the SCC, it was observed during testing that reduction in slump flow mainly happen due to formation of lumps and segregation of aggregates.

5.2 Durability Test Results

The results of compressive strengths for different percentage of fly ash as a replacement of cement after 56 days of curing in Alkaline Solution are shown in table below.

Table 2 Durability Test Results for Alkaline Solution

S. No.	Mix ID	Durability (Alkaline Ponding)	
		% weight loss	Strength (N/mm ²)
1	F-0	6.77	42.54
2	F-10	5.59	49.45
3	F-15	6.32	40.01
4	F-20	6.45	32.20
5	F-25	7.89	28.38

The results of compressive strengths for different percentage of ground fly ash as a replacement of cement after 56 days of curing in Acid Solution are shown in table below.

Table 3 Durability Test Results for Acid Solution

S. No.	Mix ID	Durability (Acid Ponding)	
		% weight loss	Strength (N/mm ²)
1	F-0	9.25	35.88
2	F-10	7.59	45.22
3	F-15	7.35	36.81
4	F-20	9.72	25.96
5	F-25	10.96	21.67

Results from the durability test on the different mixes shows that presence of fly ash in SCC noticeably reduces the effect of Acid and Alkaline chemicals on concrete. Based on the test results data, it was noticed that both strength reduction and weight loss were lower than the control mix for the replacement of cement by 15% fly ash. It was also noticed that further increase in fly ash content does noticeably increases both strength loss and weight loss.

V. CONCLUSIONS

The present study was carried out for M30 grade of self compacting concrete mix with replacement of cement with different proportions of Fly Ash (10%, 15%, 20% and 25%). It is recommended that, at minimum, Slump test, L-Box test and V-Funnel should be performed for the laboratory verification tests. Test performed on fresh concrete (i.e. Slump test, L-Box and V-Funnel) resulted in almost similar result for all different mix proportions. In durability aspect there are no significant weight loss is observed and compressive strength loss is about average 9% for salt ponding and 19% for acid ponding.

One can extend the work in this area by taking concrete grade other than M30 and by taking fly ash from the different region. The properties studied in this experimental work were compressive strength, tensile strength and Durability test of self compacting concrete. Other properties such as flexural strength, modulus of elasticity and abrasion resistance etc. can also be studied in detail.

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