AN EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF CEMENET BY USING FLY ASH AND SILICA FUME IN SELF COMPACTING CONCRETE

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ABSTRACT
In this study presents exploratory investigation Self Compacting Concrete (SCC) with the partial replacements of fly ash and silica fume. The work done made with various partial replacement of cement by silica fumes with fly ash percentage as 25%. After these replacements, cube specimens are cast and cured. The specimens are cured in water for 7, 14&28 days. The slump, V-funnel and L-Box tests are carried out on the fresh Self Compacting Concrete and in harden concrete compressive strength and split tensile strength values are concluded. Trials have been made to examine the different properties of the Self Compacting Concrete and to determine the possibility of various replacements of fly ash, silica fume that can to be used in Self Compacting Concrete.

KEYWORDS: SCC, fly ash, silica fume, L-box-Funnel etc.

INTRODUCTION
The Indian standard IS: 456-2000 permits the use of mineral admixtures for modifying the properties of concrete. The use of industrial waste products such as fly ash and silica fume, which has both pozzolanic and cementatious properties, lead to cost and energy saving.. In this study an influence of marble dust on fresh and hardened properties of fly ash induced SCC have been studied.
A World Bank and United Nations report indicates gauges that around 200 million city occupants in India will be presented to tempests and tremors by 2050.The most recent rendition of seismic zoning guide of India given in the quake safe outline code of India [IS 1893 (Part 1) 2002] allots four levels of seismicity for India as far as zone factors. As it were, the quake zoning guide of India partitions India into 4 seismic zones (Zone 2, 3, 4 and 5) dissimilar to its past variant, which comprised of five or six zones for the nation. As indicated by the present zoning map, Zone 5 expects the most abnormal amount of seismicity while Zone 2 is related with the least level of seismicity.

CONCRETE
The most popular artificial material on Earth isn't steel, plastic, or aluminum — it's concrete. Thousands of years ago, we used it to build civilizations, but then our knowledge of how to make it was lost. Here's how we discovered concrete, forgot it, and then finally cracked the mystery of what makes it so strong.
When we think concrete, we usually picture white pavements, swimming pools, and building foundations. Most of us aren't aware of concrete's fiery volcanic origin story, or that concrete is a $100 billion dollar industry. In fact, it's the most widely-used material on our planet after water. Ton for ton, humans use more concrete today than steel, wood, plastics, and aluminum combined.

SELF-COMPACTING CONCRETE (SCC) Self-compacting concrete (SCC) is a flowing concrete that does not require vibration and, indeed, should not be vibrated. It uses super-plasticizers and stabilizers to significantly increase the ease and rate of flow. It achieves compaction into every part of the mould or formwork simply by means of its own weight without any segregation of the coarse aggregate. The consistence of the concrete is specified and measured as a flow rate rather than the normal slump-test. Self-compacting concrete (SCC) is a pioneering concrete that does not involve shuddering for insertion and compaction. It is able to gush under its own load, completely filling formwork and achieve the full compaction, even in the occurrence of congested support. The hardened concrete is dense, uniform and has the same property and durability as standard vibrated concrete.

SILICA FUME Silica fume is a byproduct of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolana. Concrete containing silica fume can have very high strength and can be very durable. Silica fume is available from suppliers of concrete admixtures and, when specified, is simply added during concrete production. Placing, finishing, and curing silica-fume concrete require special attention on the part of the concrete contractor.

FLY ASH Fly ash is a fine powder which is a byproduct from burning pulverized coal in electric generation power plants. Fly ash is a pozzolana, a substance containing aluminous and siliceous material that forms cement in the presence of water. When mixed with lime and water it forms a compound similar to Portland cement.
The fly ash produced by coal-fired power plants provide an excellent prime material used in blended cement, mosaic tiles, and hollow blocks among others.
Fly ash can be an expensive replacement for Portland cement in concrete although using it improves strength, segregation, and ease of pumping concrete.

1.5 METHODLOGY

The experimental work planned in this investigation consisted of comparing mix proportioning of fly ash induced self-compacting concrete with marble dust by IS method for a given design strength in terms of cement consumption and strength achieved. The methodology adopted for the experimental work includes.
1. Mix proportioning for self-compacting concrete to achieve high flow-ability without segregation and bleeding using chemical admixture.
2. Use of marble dust as a partial replacement to cement in different dosages will be used to study the flow ability and strength of the mix proportion.
3. Slump Flow Test, J Ring Test, V Funnel Test and L Box Test will be conducted to find out the passing ability, filling ability and resistance to segregation of SCC. 4. The flow-ability test results will be compared with the limits of European standards recommended by EFNARC.
5. Compressive strength test will be conducted to examine the Compressive strength characteristics of SCC.
6. Split tensile strength test will be conducted to examine the tensile strength characteristics of SCC.

EXPERIMENTAL INVESTIGATION

3.2 MATERIAL PROPERTIES

- The materials used for this experimental investigation are cement, river sand, coarse aggregate, silica fume, fly ash, super plasticizer and water were locally available at the institute vide the construction agencies working in the institute. The succeeding subsections describes in detail about the materials used.

3.2.1 CEMENT

OPC grade 43 conforming to IS: 8112-1989 was used in the present experimental work. The various laboratory tests confirming to IS: 4031-1996 (PART 1 to 15) specification was carried out and the physical properties were found as such:

- Fineness - 0.225m^2/g
- Consistency - 30%
- Initial setting time - 30 min
- Final setting time - 600 min
- Specific gravity - 3.15

- **3.2.2 Fly ash as Cementatious material**
- Fly ash samples (fig 3.1) taken from NTPC were used in this study. Fly ash was not processed and, used as received. The sample satisfied the requirements of IS 3812(Part I).

3.3 MIX-DESIGN CALCULATION

The preamble of IS 10262-2009 is used for mix design calculations for self-compacting concrete in laboratory.

3.3.1 Test data for materials

- (a) Cement used: OPC 43 grade Conforming to IS: 8112
- (b) Specific gravity of cement: 3.15
- (c) Specific gravity of admixture
- (1) HRWR: 1.04
- (2) VMA: 1.07
- Combined specific gravity of admixture is 1.05 as 1.5% HRWR & 0.7% VMA is used.
- (d) Specific gravity of coarse aggregate: 2.74
- (e) Specific gravity of fine aggregate: 2.66
- (f) Water absorption for Coarse aggregate: 0.755
- (g) Water absorption for Fine aggregate: 1.35
- (h) Free (surface) moisture
- (1) Coarse aggregate: Nil
- (2) Fine aggregate: Nil
- (i) Sieve analysis:
- (1) Coarse aggregate: 16mm graded
- (2) Fine aggregate: zone III

3.3.3 Calculation for water content

- Maximum water-cement ratio for M-60 Grade concrete is taken = 0.4, by experience take w/c= 0.36 < 0.45
- Maximum size of aggregate is taken as 16mm.
- Water content is calculated as per IS: 10262-2009, = (208)+(186-208)x(16-10) = 194.8 =195lts. (20-10)
- As per IS :10262-2009, For every increase in 25mm slump from 50mm, increase the water content by 3% for each set of 25mm slump therefore for maximum slump 300mm,
- Water content = 195+ (30 X 195) = 253.3 liters.
- For Using super-plasticizer @ 2.2% of cement the water content was reduced by 30%.
- **Water content = 0.7 x 253.5 = 177.45 liters**
- **3.3.4 Cement and fly ash calculation**
- Taking w/c ratio 0.38
- Cement content = 178/0.38 = 468.42 ≈ 468 kg/m3
- Mixed design when fly ash 30% and (SUPER PLASTICIZER + VMA) 2.2% are consider
  $C = C_1 + Kf$
- From **IS 10262:2009**
- Fly ash = 468 x 0.3 = 140.4 Kg.
- Cementatious material = 390.78+140.4 = 531.18
- (Water /powder ratio) = 0.36
- Water = 191.22 ≈ 191 kg
- Further reducing the cement by adding 8% fly-ash and silica fume by weight of cement
- Cement content = 0.92 x 390.78 = 359.52 kg
- For water-powder ratio = 0.36

- Volume of coarse aggregate corresponding to 16mm size aggregate and fine aggregate (zone III) for water-cement ratio of 0.5 is as IS: 10262- 2009.

3.4 FLOWABILITY TEST

The basic difference between self-compacting concrete and normally vibrated concrete is their fresh properties. Workability is the primary requirement of SCC. The various aspects of workability characteristic are

- Flow-ability
- Viscosity
- Passing ability and
- Segregation resistance

If all the workability characteristics are fulfilled as per the acceptance criteria for self-compacting concrete (EFNARC: 2002) given in table 3.8, then concrete mix can be termed as SCC. The fault finding for low results and high results as per EFNARC: 2002are given in table 3.9 and table 3.10. The succeeding sub sections details the various flow-ability tests.

3.4.1Slump flow test

The slump flow test (EFNARC 2002 which is pictured below is the simplest and most commonly used test method for SCC.

The flow-ability and the flow rate of SCC without obstructions is assured by Slump flow and T500. The result indicates the filling ability of SCC, and the T500 time measures the speed of flow. Finally, the viscosity of the paste can be visualized.

A good estimation of filling ability can be determined by Slump flow and T500 test. A slump flow value of 650mm at least is required for SCC.

Further, the T50 time is one of the indications of flow-ability for SCCs mixes. If the flow time is between 2-5 seconds then it is useful or acceptable for housing application and if the flow time is within 3-7 sec then it is acceptable for civil engineering purposes.

3.4.2 J- RING TEST

The J-Ring test (EFNARC 2002) extends common filling ability test methods in order to characterize passing ability of self-consolidating concrete mixtures. The J-Ring test device can be used with the slump flow test or v-funnel test.

The test apparatus as developed is shown in figure below and is used to determine the passing ability of the concrete. The spacing of the bars is in accordance with normal reinforcement provided at the construction sites. However, three times the size of maximum aggregate is considered to be suitable.

The J-Ring is used in combination with the Slump flow or eventually even the V funnel test assesses the flowing ability and the passing ability of the concrete.

3.4.3 L-Box test

This test method provides a procedure to determine the passing ability of SCCs mixes. The SCC is allowed to pass through the specified gaps of reinforcing bars; the maximum height reached by the SCC is measured. This measured height indicates the blocking characteristics of SCC.

L-box has arrangement and the dimensions as shown in Figure. The H_2/H_1 ratio is known as blocking ratio. Blocking ratio in the range of 0.8 to 1 has been recommended by the EU research team and by EFNARC (2002).

3.4.4 V-Funnel test

The V-Funnel Test equipment developed in Japan consists of a V-shaped funnel. Arrangement and the dimensions are shown in Figure.

It determines the ability to fill (flow-ability) of SCC with a maximum aggregate size of 20mm. This test measures the ease with which the concrete flows. If the flow time of concrete through the V funnel is less than 10 seconds then the concrete can be classified as SCC. The inverted cone shape of the funnel is assumed to restrict the flow, and extended flow times gives indication of the vulnerability of the mix to blocking

3.5 TESTS FOR STRENGTH IN COMPRESSION

Two types of compression test specimens are used: cubes and cylinder. In the present work cube specimens were preferred. 150mm size Cube Moulds conforming to IS code IS: 10086-1982. The concrete cubes were caste in the mould. After 24 hours the sample were removed from the mould and then cured in clean water at normal room temperature for 28 days. After 28 days the cubes were left to dry for 2 or 3 hours.

The specimens were tested for compressive strength on compression testing machine. The load were applied and increased continuously at a constant rate of 140/cm^2/min (approx.) until the specimen breaks.

3.6 SPLIT TENSILE STRENGTH TEST

This is also sometimes referred as “Brazilian Test” as this test was developed in Brazil in 1943. This comes under indirect tension test methods. Cylindrical specimen was placed horizontally between the loading faces of a compression testing machine the load was applied along the vertical diameter of the cylindrical sample. A concrete cylinder of size 150mm diameter and 300mm height was subjected to the action of a compressive force along two opposite edges.

Horizontal tensile stress = 2P/Π D L

Where P = Compressive load on the cylinder.

L = Length of cylinder.

D = Diameter of cylinder

In the present investigation, the split tensile strength test has been conducted on desired grade of SCC at 28 days.

The acceptance criteria of self-compacting concrete are given in table 3.8 and fault finding in results are given in table 3.9 and table 3.10 as per EFNARC 2002.

RESULTS AND CONCLUSIONS

Mix No.	% of Fly ash and silica-fume by Weight of Cement	Compressive Strength Test Results of Cube (28 Days)
1	0	42.86
2	4	43.85
3	8	44.94

Mix No.	% of Fly Ash and-silica-fumeby Wtof Cement	L Box Test	V-Funnel Test
		H_2/H_1	Time in sec
1.1	0	0.8	10.8
2.2	4	1	8.6
3.3	8	0.98	9.7
4.4	12	0.94	10.2
5.5	16	0.86	10.8
6.6	20	0.93	10.4

1. The slump flow varied between the ranges of 655-725 mm
2. Addition of fly ash nullified the stickiness observed in mixes without silica fumes and further, the mixes were highly cohesive.
3. Increase in percentage of fly ash content from 0% to 8 %, an increase in compressive strength was recorded.
4. At 6% replacement of fly ash by weight of cement the increase in compressive strength was 7% while the increase was about 9% when percentage replacement was 8% as compared with reference mix.
5. At 10% replacement of fly ash with cement there was slight decrease in compressive strength as compared to 4,6 and 8% replacement of silica fumes by weight of cement
6. The values of splitting tensile-strength range between 3 and 4 MPa.
7. The increase in split tensile strength is almost 10% at 2% replacement and 13% at 4% replacement of fly ash by weight of cement.
8. The increase in split tensile strength is almost 20% at 6% and 8% replacement of fly ash by weight of cement.
9. However at 10% replacement the increase in split tensile strength is only about 9%.

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