Investigation of utilization of Flyash in Self Compacting Concrete

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Abstract: The current study addresses the results of an incremental study carried out over the feasibility of utilization of flyash in the self compacting concrete with an effort to reduce the consumption of cement leading to reduced greenhouse gas emission corresponding to the production of cement. Flyash was added on various dosages to the self compacting concrete along with the super plasticizer. Various ingredients were proportioned based on the Japanese method. The mix that passed the EFNARC guidelines were tested for the mechanical properties such as compressive strength, split tensile strength and flexural strength. Fair results have been obtained and this study unleashes a great potential for the utilization of flyash in self compacting concrete.

Keywords: Self compacting concrete, flyash, passing ability, flowing ability, workability

1. Introduction

Self compacting concrete witnessed its developing phase from the early eighties due to its rheological advantages. Self compacting concrete (SCC) is a special type of concrete that compacts itself without the help of vibrators or rods [1, 2]. SCC must satisfy the workability criteria particularly passing ability and flowing ability. They determine the primary characteristic of the self compacting concrete to pass flow to different portions under congested conditions. The second important property of SCC is that it should be stable enough to maintain in that portion without segregation and bleeding. Segregation and bleeding are the delicate problems in the SCC. The main purpose of this type of concrete is to offer more freedom to designers, reduce the compaction problems in the construction site and mitigate the constructional flaws arising in the site. Due to its high deformability and resistance to segregation, it has the capacity to completely fill the formwork, easy to flow in complex forms with congested reinforcement and encapsulate the reinforcement without any influence of the workers skills. They offer high pump ability, durability and high structural performance. They also reduce the labour force required in the site for concreting [3-5].

Cement production leads to increased air pollution and also mining activities. They affect the environment and the ecosystem to the large extent [6]. Hence efforts must be made to reduce the production of cement which relies upon the reduced consumption of cement. Flyash is the by product of the thermal power plant and possess large capacity to replace the cement. It is extensively used to develop Geopolymer concrete to yield great engineering properties. [7, 8]. Utilization of flyash also reduces the adverse effects caused due to the cement production. It also adds for the durability of the concrete. This fly can be added as an admixture to the concrete while manufacturing[9].

In this study an approach has been made to utilize the flyash in SCC and study its engineering properties. The main objective of this study is to study the flowing ability, passing ability of the self compacting concrete and then to conduct the mechanical properties tests such as compressive strength test, split tensile strength test and flexural strength test.
2. Materials
The various materials used in this experimental work to make Self Compacting Concrete are Flyash, Cement, Fine aggregate, Coarse aggregate, water, super plasticizer.

2.1 Flyash
Flyash in this work were collected from Tutucurin Thermal Power plant. Specific gravity of flyash was found to be 2.5.

2.2 Cement
Cement in this experimental program was free from lumps. Specific gravity of Cement was found to be 3.15. Fineness test was performed and found to be 5 percent. Consistency of cement was found to be 34%.

2.3 Coarse Aggregate
Coarse aggregates of size 20mm was used in this test. Specific Gravity of coarse aggregate was found to be 2.55. Fineness modulus of coarse aggregate was found to be 7.4%.

2.4 Fine Aggregate
Fine modulus of Fine aggregates was found to be 4.57. Specific gravity of fine aggregate was found to be 2.55.

2.5 Water
Ph of the water was found to be 7.18. Hardness of the water was found to be 275mg/l of CaCO3.

2.6 FosrocConplast (Sp 430)
It is a water reducing and water proofing admixture used for all types of concrete. It conforms to IS 9103-1999, IS 2645-1975. It is required at a very small dosage and hence convenient to handle and implies greater economy.

3. Experimental Program:
The Experimental program consists of determining the optimum mix for the self compacing concrete using Flyash along with cement in the presence of Plasticizer. There is no proper procedure available for design of SCC, hence the final mix proportions were designed based on THE Japanese method in which various proportion of W/C ratio have been tried to arrive at the mix giving the appropriate workability which meets the self compacting standards (EFNARC guidelines)[10].

All the ingredients were first mixed in dry condition for 1 minute then 70% of water was added to dry mix and mixed thoroughly 1 minute remaining 30% of water divided into 2 parts i.e., 20% and 10%. 20% of water mixed with Conplast SP 430 (super plasticizer) was poured into already mixed concrete and mixed for four minutes. The various specimen details and the mix proportions are tabulated in Table 1.

| MIX     | CEMENT (Kg/m³) | F.A (Kg/m³) | C.A (Kg/m³) | FLY ASH (Kg/m³) | Super Plasticizer (lit/m³) | Water (lit/m³) |
|---------|----------------|-------------|-------------|-----------------|---------------------------|---------------|
| TMSCC1  | 435            | 926         | 688         | 48              | 4.8                       | 212           |
| TMSCC2  | 435            | 926         | 668         | 48              | 4.8                       | 235           |
| SCC1    | 435            | 926         | 648         | 48              | 4.8                       | 264           |
| TMSCC3  | 450            | 856         | 760         | 120             | 4.5                       | 180           |
| TMSCC4  | 450            | 856         | 740         | 120             | 5                         | 232.3         |
| SCC 2   | 450            | 856         | 716         | 120             | 5                         | 255.38        |
| TMSCC5  | 465            | 910         | 590         | 85              | 5                         | 227.14        |
MIX  |  CEMENT (Kg/m³)  |  F.A (Kg/m³)  |  C.A (Kg/m³)  |  FLY ASH (Kg/m³)  |  Super Plasticizer (lit/m³)  |  Water (lit/m³)  
---|---|---|---|---|---|---
TMSCC6  |  465  |  880  |  620  |  85  |  5  |  231.81  
SCC 3  |  465  |  850  |  650  |  85  |  5  |  236.36  

The workability tests and the mechanical properties of the self compacting concrete were found out for the specimens of standard size using the standard ASTM procedures [11, 12].

4. Test and Results:
4.1 Filling Ability:
4.1.1 Slump Flow test:
Filling ability of SCC is found out using the Slump Flow test. This measures the flowing capacity of SCC in the horizontal direction when there are no obstacles. The flow of concrete under unconfined condition is found out using Slump flow test. The values are tabulated in Table 2.

| Mix  | Slump Cone Test (mm) | EFNARC Guidelines for Slump Cone Test (mm) |
|------|----------------------|------------------------------------------|
| TMSCC1  | 430                   |                                         |
| TMSCC2  | 520                   |                                         |
| SCC1    | 625                   |                                         |
| TMSCC3  | 420                   |                                         |
| TMSCC4  | 500                   |                                         |
| SCC 2    | 550                   | 600-800                                 |
| TMSCC5  | 450                   |                                         |
| TMSCC6  | 530                   |                                         |
| SCC 3    | 530                   |                                         |
| TMSCC7  | 550                   |                                         |
| TMSCC8  | 580                   |                                         |
| SCC4    | 650                   |                                         |

4.1.2 V Funnel test:
Flow ability of SCC is ascertained using V Funnel test. This method also determines the filling capability of SCC. The values are tabulated in Table 3. The results were found to be in accordance with the values obtained using Slump cone test.

| Mix  | V – Funnel Test(S) | EFNARC Guidelines for V - Funnel Test (S) |
|------|-------------------|------------------------------------------|
| TMSCC1  | 11                |                                         |
| TMSCC2  | 9                 |                                         |
| SCC1    | 6                 | 6-12                                     |
| TMSCC3  | 16                |                                         |
| TMSCC4  | 14                |                                         |
Mix V – Funnel Test (S) EFNARC Guidelines for V - Funnel Test (S)

SCC 2 8
TMSCC5 12
TMSCC6 10
SCC 3 12

It has been found that SCC1, SCC2, SCC3 were found to be in order with the EFNARC Guidelines.

4.2 Passing Ability:
Passing Ability of the concrete was performed to measure the ability of concrete to pass through the narrow openings and fill in the small gaps. This test truly measures the important property of SCC to pass through the congested reinforcements. The values are tabulated in Table 4.

Table 4. L-Box Test results

| Mix       | L – Box Test (h2/h1) | EFNARC Guidelines for L - Box Test (h2/h1) |
|-----------|----------------------|-------------------------------------------|
| TMSCC1    | 1.5                  |                                           |
| TMSCC2    | 1.2                  |                                           |
| SCC1      | 0.85                 |                                           |
| TMSCC3    | Blocking             |                                           |
| TMSCC4    | 1.1                  | 0.8-1.0                                   |
| SCC 2     | 0.9                  |                                           |
| TMSCC5    | Blocking             |                                           |
| TMSCC6    | 1.2                  |                                           |
| SCC 3     | 0.8                  |                                           |

From the table 2, table 3 and table 4 it is witnessed that SCC1, SCC2, SCC3 were found to be in accordance with EFNARC Guidelines. Hence further investigation over mechanical properties of self compacting concrete was done over these specimens.

4.3 Compressive Strength Test:
The cubical specimens which passed the fresh property test were tested for compressive strength after 7 days and 28 days. The values are tabulated in Table 5. Figure 1 depicts the variation of compressive strength for the various proportions of SCC.

Table 5. Compression test results

| Mix       | Compression Strength 7 Days (N/mm$^2$) | Compression Strength 28 Days (N/mm$^2$) |
|-----------|----------------------------------------|----------------------------------------|
| SCC 1     | 10.5                                   | 14.88                                  |
| SCC 2     | 13.9                                   | 16.02                                  |
| SCC 3     | 11.25                                  | 15.84                                  |
From Figure 1, it is observed that the compressive strength of the SCC increased with the addition of flyash. Also, it is observed that SCC attains about seventy percent of the twenty-eight days strength in seven days.

### 4.4 Split tensile strength

Cylindrical specimens of diameter 150 mm and height 300 mm were cast and tested in the Universal testing machine after 7 days and 28 days. The results are tabulated in Table 6. The variation of the split tensile strength can be well depicted in the figure 2.

| Mix   | Cylinder Splitting Strength 7 Days (N/mm²) | Cylinder Splitting Strength 28 Days (N/mm²) |
|-------|------------------------------------------|--------------------------------------------|
| SCC 1 | 1.96                                     | 2.3                                        |
| SCC 2 | 1.76                                     | 2.1                                        |
| SCC 3 | 2.1                                      | 2.6                                        |

Split tensile strength of the SCC was found to increase with the increase in flyash content.

### 4.5 Flexural Strength

Prismatic Specimens of size 500 X 100 X 100 mm were casted and tested for the flexural strength at 28 days and the results are tabulated in Table 7. Variation of the flexural strength with the flyash content can be well depicted from the figure 3.
Table 7. Flexural Strength test results

| Mix   | Flexural Strength 28 Days (N/mm²) |
|-------|----------------------------------|
| SCC 1 | 4.3                              |
| SCC 2 | 4.1                              |
| SCC 3 | 3.8                              |

It has been found that there is a slight decrease in the flexural strength of SCC with the addition of flyash.

5. Conclusion
From the above discussions the following conclusions can be drawn.
- With the increase in super plasticizer content the workability increases and it falls in the region required by the guidelines.
- Also it has been found that the compressive strength of the self compacting concrete increases with the increase in flyash content.
- There has been a slight increase in the split tensile strength with the sustained incorporation of flyash.
- Flexural strength has been found to decrease with the addition of flyash in the self compacting concrete.

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