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# Comparison of the Performance of Self Compacting Concrete

***Rajasekaran.D, Aravind Prabu.S, Karthik.S**

**Department Of Civil Engineering, Sasurie Academy of Engineering Coimbatore, India**

**Abstract :** Self-Compacting Concrete Originally developed in Japan, SCC technology was made possible by the much earlier development of Superplasticisers for concrete. Tocompare the performance of SCC with Fly Ash 20%, Silica Fume 10%, Rice Husk Ash (5%, 10%, and 15%) as a partial replacement of cement, due to the high increase in construction which has brought a heavy demand for ingredients of concrete such as cement and sand, and these materials are becoming costly and scarce. The use of self-compacting concrete (SCC) is spreading worldwide because of its very attractive properties in the fresh state as well as after hardening. By using Super plasticizer (High Range Water Reducing Admixture) to increase the workability & admixture should bring about the required water reduction & fluidity but should also maintain the dispersing effect. The Using M40 grade of concrete with curing period of 7days, 14days and 28days.To Study the workability and mechanical properties of Self-Compacting Concrete & Compare to Conventional Self-Compacting Concrete. The laboratory testing included slump flow test, L-Box test, V-Funnel test, compressive strength test, and splitting tensile strength test.
**Keywords :** Self-Compacting Concrete, Silica Fume, Rice Husk Ash, Fly Ash, Super plasticizer, Material Testing.

## I. Introduction

Self-compacting Concrete (SCC) that is able to flow and consolidate under its own weight, completely fill the formwork even in the presence of dense reinforcement, while maintaining homogeneity and without the need for any additional compaction. In principle, a self – compacting or self – consolidating concrete must:

- Have a fluidity that allows self – compaction without external energy
- Remain homogeneous in a form during and after the placing process and
- Flow easily through reinforcement

Self – consolidating concrete has recently been used in the pre – cast industry and in some commercial applications, however the relatively high material cost still hinders the wide spread use of such specialty concrete in various segments of the construction industry, including commercial and residential construction.

Compared with conventional concrete of similar mechanical properties, the material cost of SCC is more due to the relatively high demand of Cementation materials and chemical admixtures including high – range water reducing admixtures (HRWRA) and viscosity enhancing admixtures (VEA). Typically, the content in Cementation materials can vary between 450 and 525 $kg/m^3$ for SCC targeted for the filling of highly restricted areas and for repair applications. Such applications require low aggregate volume to facilitate flow among restricted spacing without blockage and ensure the filling of the formwork without consolidation. The incorporation of high volumes of finely ground powder materials is necessary to enhance cohesiveness and increase the paste volume required for successful casting of SCC. The SCC essentially eliminates the need for vibration to consolidate the concrete. This results in an increase in productivity, a reduction in noise exposure and a finished product.

## II. Literature Review

**Hajime Okamura & Masahiro Ouchi (2003) were described "Self-Compacting Concrete" Journal of Advanced concrete technology volume 1**.Self-Compacting Concrete was first developed in 1988to achieveDurable concrete structures.In early 1983, the problem of the durability of concrete structures was a major topic of interest in Japan. The creation of durable concrete structures requires adequate compaction by skilled workers.Okamura solved the issue of degrading quality of concrete construction due to lack of compaction by the employment of SCC which is independent of the quality of construction work.The prototype of SCC was completed in 1988.This concrete was named as "High performance concrete" as follows at 3stage

Early age : Avoidance of initial defect
Fresh state : Self-compactable
After hardening : Protection against external Factors.

The method for achieving self-compatibility involves not only high deformability of paste (or) mortar, but also resistance to segregation between coarse aggregate & mortar when the concrete flows through the confined zone of reinforcing bars. When self-compacting concrete become so widely used that it is seen as the "Standard Concrete" rather than a "Special Concrete", we will have succeeded in creating durable &reliable concrete structures that require very little maintenance work.

**N R Gaywala& D B Raijiwala (2006) was done on "Self-Compacting Concrete: A Concrete of Next Decade" Journal of Engineering Research and Studies**. The specimens were casted by M25 grade of concrete. They studied the effect of different proportion of Fly Ash (15%, 25%, 35%, 45%, and 55%) in concrete. The maximum compressive strength, split tensile strength, flexural strength & pull out strength for self-compacting concrete can be obtained by addition of 15% of fly ash in mix as compared to addition of 25%, 35%, 45% and 55% cement replacement by fly ash.SCC gives good durability properties as compared to the ordinary concrete

**Gopala Krishna Sastry& Asha Deepthi. Deva (2015) was done on "A Comparative Study on Mechanical Properties of Normal Vibrated Concrete and Self-Compacting Concrete"International Journal of Civil and Structural Engineering Research**. The specimens were casted by M30 grade of concrete. They studied the effect of different proportion of Fly Ash 30 % & Silica Fume 10% in concrete.NVC of M30 grade is designed as per IS code - 10262:2009 and attained compressive strength 39.52 N/mm2 at 28 days.SCC with 30% FA addition gives nearly same strength of NVC of same grade.SCC with 10% SF addition gives nearly same strength of NVC of same grade.SCC containing 30% FA & 10% SF obtained maximum compressive strength , split tensile strength & flexural strength .The percentage increase in compressive strength, split tensile strength and flexural strength at 30% FA & 10% SF for SCC M30 grade is 23.89%, 18.77%, 20.31% more than that of SCC without mineral admixture.

**Mayur B. Vanjare&Shriram H. Mahure (2012) were described "Experimental Investigation on Self-Compacting Concrete Using Glass Powder" International Journal of Engineering Research and Applications**. The specimens were casted by M20, M25, and M30 grade of concrete. They studied the effect of different proportion of Glass Powder (5%, 10%, and 15%) in concrete.The flow value decreases by an average of 1.3%, 2.5% and 5.36% for glass powder replacements of 5%, 10% and 15% respectively. The average reduction in compressive strength for all grades was around 6%, 15% and 20% for glass powder contents of 5%, 10% and 15% respectively.The average reduction in flexural strengths for all grades was around 2%, 3.7% and 6.75% for glass powder contents of 5%, 10% and 15% respectively.

**Selvamony Cet al (2009) was done on "DEVELOPMENT OF HIGH STRENGTH SELF-COMPACTED SELF-CURING CONCRETE WITH MINERALADMIXTURES" International Journal on Design and Manufacturing Technologies**. In this study, the effect of replacing the cement, coarse aggregate and fine aggregate by limestone powder (LP) with silica fume, quarry dust and clinkers respectively and their combinations of various proportions on the properties of SCC has been compared. Silica fume was observed to improve the mechanical properties of SCC, while lime stone powder along with quarry dust affected mechanical properties of SCC adversely. From the test result a maximum of 8% of lime stone powder with silica fume, 30% of quarry dust and 14 % of clinkers was able to be used as a mineral admixture without affecting the self-compactability.

**Ramanathan P et al (2013) was done on "Study on Durability Characteristics of Self-Compacting Concrete with Fly Ash" Jordan Journal of Civil Engineering**. They studied the effect of different proportion of Fly Ash (10%, 20%, 30%, 40% and 50%).The durability of concrete is tested by acid resistance, sulphate attack and saturated water absorption at the age of 28, 56 and 90 days. From the test result 30% replacement of fly ash, the fresh properties observed were good as compared to 10%, 20%, 40% and 50% fly ash replacement. Saturated water absorption percentage decreases with the increase in fly ash. For 30%replacement of fly ash, the lower water absorption level is a good. Compressive strength loss decrease with the increase in fly ash in concrete.

**Chandra Mohan G (2015) was done on "A Study on Properties of Self-Compacting and Self-Curing Concrete" International Journal of Advanced Research Trends in Engineering and Technology**. The specimens were casted by M40 grade of concrete.The SCC were cured under three different curing conditions being normal curing (NC), membrane curing (MC) and self-curing (SC).The compressive strength of the self-compacted self-curing concrete is more than other curing methods like normal and membrane curing types. The compressive strength of self-compacting concrete is getting more than the conventional concrete. It is found that the ratio of gain in strength is almost same or even better than that of conventionally vibrated concrete.

**Deepa Balakrishnan S et al (2013) were described "Workability and strength characteristics of self-compacting concrete containing fly ash and dolomite powder" American Journal of Engineering Research (AJER)**. The specimens were casted by M20 grade of concrete.In this paper, high volume fly ash self-compacting concrete was produced with 12.5% , 18.75% , 25% , and 37.5% of the cement (by mass) replaced by fly ash and 6.25% , 12.5% and 25% of the cement replaced by dolomite powder. Better mechanical and physical properties of concrete can be obtained with the replacement of cement with fly ash from 12.5 percent to 18.75 percent. Better fresh properties of SCC can be obtained with the replacement of cement with dolomite powder from 6.25 percent to 12.5 percent. From this experimental study it can be inferred that fly ash and dolomite powder blend well to improve the overall workability, which is the prime characteristics of SCC.

**Mr. Bharath E et al (2015) was done on "Effect of Partial Replacement of Cement in Self-Compacting Concrete by Fly Ash and Metakaolin"International Journal of Engineering Research & Technology (IJERT)**. The specimens were casted by M40 grade of concrete. They studied the effect of different proportion of Fly Ash (5%, 15%, and 25%) &metakaolin (3%, 6%, and 9%).Replacement of cement by a combination of fly ash and metakaolin in the range of 8 to 34 percent has no adverse effect on the workability properties of SCC. As the percentage of cement replacement increases, the 7 days and 28 days compressive strength of SCC cubes increase up to 24 % and later decrease .The maximum splitting tensile strength of SCC cylinders at 28 days occurs for a percentage of cement replacement = 14 in the considered range. The minimum splitting tensile strength at 28 days occurs for a percentage of cement replacement = 28 in the considered range.The initial tangent modulus of SCC is a function of the 28 days compressive strength. As the strength increases the modulus also increases.

**Ahmed Fathi et al (2013) was done on "STUDY THE EFFECTIVENESS OF THE DIFFERENT POZZOLANIC MATERIAL ON SELF-COMPACTING CONCRETE" ARPN Journal of Engineering and Applied Sciences**. This paper presents the study on the effect of fly ash (FA), silica fume (SF) and microwave incinerated Fly Ash (MIRHA) as cement replacement material (CRM) on the mechanical and fresh properties of self-compacting Concrete (SCC). The result showed that the MIRHA needed more water as compared to SF to achieve the similar fresh properties, similarly concrete with 5% SF showed about 9.70% higher compressive strength after 90 days, 5.10 MPa high tensile strength and 10.12 MPa flexural strength when compared with other mixes. 5% SF and 30% FA mixes showed highest compressive strength as compared to the control mix. Whereas all CRM mixes resulted in high flexural strength, which was due to the negligible bleeding and high cohesiveness. Silica fume requires less water demand as compared to MIRHA for achieving the similar fresh properties.

## III. Material Study and Test Results

### A. General

The self-compacting considered here is prepared by the following ingredients ASTM Type II Portland cement, fine sand (approximately 150-500 μm), and Naphthalene super plasticizer 553.

### B. Cement

Ordinary Portland Cement 53 grade cement can be used.

### C. Fly Ash

SCC is produced with high quantity of powder or fine materials. In majority of cases SCC is used with Fly Ash.

Where **Class-F Fly ash** normally produced burning anthracite or bituminous coal, usually has less than 5% CaO. Class F fly ash has pozzolanic properties only. This fly ash is pozzolanic in nature, and contains less than 20% lime (CaO).

### D. Silica Fume (SF)

Silica fumes also referred to as micro silica or condensed silica fume, is another material that is used as a pozzolonic admixture. It is a product obtained from reduction of high purity quartz with coal in an electric furnace in the manufacture of silicon or ferrosilicon alloy.

The use of silica fume in conjunction with super plasticizer has been the backbone of modern high performance concrete. For higher strengths, the use of silica fume is essential. Highly reactive pozzolan used to improve mortar and concrete.

### E. Rice Husk Ash (RHA)

Rice husk Ash, is obtained by burning rice husk in controlled manner without causing environmental pollution. Rice husk Ash exhibits high pozzolanic characteristics and contribute to high strength and high impermeability of concrete. Rice husk Ash essentially consist of amorphous silica (90%$SiO_2$).India produces about 122 million ton of paddy every year .Each ton of paddy producers about 40Kg of RHA.

### F. Fine Aggregate

Fine aggregate should be properly graded to give minimum void ratio and be free from deleterious materials like clay, silt content and chloride contamination etc. It can be natural or manufactured. The grading must be uniform throughout the work. The moisture content or absorption characteristics must be closely monitored as quality of SCC will be sensitive to such changes.

Particles smaller than 0.125mm (125μ) size are considered as fine which contribute to the powder content. Fine aggregates shall conform to the required of IS 383. The sand was washed and screened at site to remove deleterious materials and tested as per the procedure given in IS: 2386-1968 and the results were tabulated.

### G. Coarse Aggregate

The coarse aggregate chosen for SCC is typically round in shape, is well graded, and smaller in maximum size than that used for conventional concrete typical conventional concrete could have a maximum aggregate size of 40 mm or more. In general, a rounded aggregate and smaller aggregate particles aid in the flow ability and deformability of the concrete as well as aiding in the prevention of segregation and deformability of the concrete as well as aiding in the prevention of segregation. Gradation is an important factor in choosing a coarse aggregate, especially in typical uses of SCC where reinforcement may be highly congested or the formwork has small dimensions. Gap – graded coarse aggregate promotes segregation to a greater degree than swell-graded coarse aggregate. As with conventional concrete construction, the maximum size of the coarse aggregate for SCC depends upon the type of construction. Typically, the maximum size of coarse aggregate used in SCC ranges from approximately 10 mm to 20 mm.

**E. Chemical Admixture**

Admixtures may be defined as the materials other than the basic ingredients of concrete i.e. cement, aggregates and water added to the concrete mix immediately before and during the mixing process to modify one or more specific properties of concrete in fresh and hardened state.

Superplasticiser are an essential component of SCC to provide necessary workability. To improve the workability of self-compacting concrete we have to add some plasticizers (water reducers) as a chemical admixture.

While naphthalene based superplasticiser are popularly used in conventional concrete, SCC is associated more with polycarboxylic ether based superplasticiser. These have been most recently developed, and are sometimes referred to as “new generation” super plasticizers. The difference in functional mechanism between these two types and general compatibility of the latter with major types of cement could be reasons for this trend.

In my project, I am going to use polycarboxylic ether based super plasticizer Naphthalene Super Flow complying with ASTM C-494 type F.

**F. Compressive strength of concrete:**

Compressive strength of concrete is defined as the load, which causes the failure of a standard specimen. (Ex 150 mm cube according to ISI) divided by the area of cross section in uniaxial compression under a given rate of loading. The test of compressive strength should be made on 150mm size cubes.

Place the cube in the compression-testing machine. The green button is pressed to start the electric motor. When the load is applied gradually, the piston is lifted up along with the lower plate and thus the specimen application of the load should be 300 KN per minute and can be controlled by load rate control knob. Ultimate load is noted for each specimen. The release valve is operated and the piston is allowed to go down. The values are tabulated and calculations are done.

**G.Split tensile strength**

A concrete cylinder of size 150mm dia×200mm height is subjected to the action of the compressive force along two opposite edges, by applying the force in this manner .The cylinder is subjected to compression near the loaded region and the length of the cylinder is subjected to uniform tensile stress.

Horizontal tensile stress=$2P/\pi DL$
Where, P=the compressive load on the cylinder.
L=length of the cylinder
D=dia of cylinder

## Iv. Test Results

### Test Results for Workability

SCC- Trial mix details are explained below
Trail 1 = C+FA+CA+W + 0.4 % SP
Trail 2 = C+FA+CA+W + 0.9 % SP
Trail 3 = C+FA+CA+W + 1.2 % SP

The following table shows the SCC Trial mix Workability test results.

| **MIX** | **Slump Flow (mm)** | **L-Box Test (mm)** | **V-Funnel Test ( sec)** |
|---|---|---|---|
| Trail 1 | 520 | 0.6 | 1.25 |
| Trail 2* | 590 | 0.7 | 2 |
| Trail 3 | 670 | 1 | 2.5 |

* Best Trail mix = SCC
SCC Mix = C+FA+CA+W+1.2% SP

The following table shows the comparison ofcompressive strength of Conventional Self-Compacting Concrete, and Mixing Self-Compacting Concrete.

| Type | **7 days (N/mm2** | **14 days (N/mm2)** | **28 days (N/mm2)** |
|---|---|---|---|
| SCC | 27.66 | 30.85 | 47.47 |
| Mix-1 | 28.83 | 31.38 | 48.9 |
| Mix-2 | 29.67 | 32.55 | 48.57 |
| Mix-3 | 28.9 | 32.35 | 46.57 |

The Split Tensile Strength of Conventional Self-Compacting Concrete, and Mixing Self-Compacting Concrete.

| **Type** | **7 days (N/mm2** | **14 days (N/mm2)** | **28 days (N/mm2)** |
|---|---|---|---|
| SCC | 3.02 | 3.6 | 4.12 |
| Mix-1 | 3.09 | 3.54 | 4.08 |
| Mix-2 | 3.16 | 3.62 | 4.21 |
| Mix-3 | 3.08 | 3.6 | 4.11 |

## V. Conclusion

To increase the stability of fresh concrete using increased amount of fine materials in the mixes. Some of the cement replacement material has positive effects on self- compacting concrete; mechanical and fresh properties.The amount of aggregates, binders and mixing water, as well as type and dosage of super plasticizer to be used are the major factors influencing the properties of SCC. Slump flow, V-funnel, L-flow, U-box and compressive strength, Split tensile strength tests were carried out to examine the performance of SCC.The maximum Expected compressive strength, Split tensile strength for self-compacting concrete can be obtained by addition of 20% of fly ash, 10% of Silica Fume & 10% Rice Husk Ash mix as compared to addition of 5% & 15% of cement replacement by Rice Husk Ash.

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