# Evaluation of Mechanical Properties of High Performance Self Compacting Concrete using : Silica Fume, GGBS and Fly Ash

**Ganatra Dhaval Vikram[1], Dr. Kalpana Maheshwari[2]**

[1]*P.G. Student, Master of Structural Engineering-HJD Institute Kera-Kachchh,Gujarat,India*
[2]*H.O.D Civil Engineering Department- HJD Institute Kera-Kachchh,Gujarat,India*

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**Abstract -** *Need for economic construction material is essential nowadays in order to obtain higher strength for high rise buildings and for structures carrying heavy loads at a lower cost. Development in technology demands rapid construction techniques for which supplementary cementitious materials can be used to obtain the desired mechanical strength and durability properties for the structure which includes the use of Fly Ash,GGBS( Ground Granulated Blast Furnace Slag),Metakaoline ,Silica fume in definite proportions in concrete mix.The aim of present work is to understand the behavior of High Performance Self Compacting concrete containing Supplementary cementitious materials towards strength and durability in order to get the desired strength along with reduction in material cost of concrete.*

***Keywords** : GGBS, Silica Fume, FlyAsh, Superplasticizer, V-Funnel, L-Box, $T_{50}$ , Slump Flow, Compressive Strength Test.*

## 1.INTRODUCTION

For Large Massive Structures Conventional concrete does not show the desired characteristics properties such as durability, mechanical strength , Cost effectiveness, and various others. Concrete mix design containing supplementary cementitious materials(SCM's) such as Silica fume, Ground Granulated Blast Furnace Slag, Fly ash, Metakaoline, Alccofine in definite proportions may show better results in terms of strength, durability, mechanical strength etc. as compared to conventional concrete.

### 1.1 Purpose Of SCC

The main reasons for employment of self Compacting Concrete are :

- To shorten construction period.
- To assure compaction in structure especially in confined zones where vibrating compaction is difficult.
- To eliminate noise due to vibration.
- To reduce environmental impacts.

## 2. MATERIALS

a) Cement
b) Water.
c) Fine aggregate (sand),
d) Coarse aggregate
e) Silica Fume
f) GGBS
g) Fly Ash
h) Super plasticizer

### a) Cement

Ordinary Portland cement of 53-grade was used as it satisfied the requirements of IS: 269- 1969 and results have been tabulated in table 1.

| | | |
|---|---|---|
| Initial setting time | | 27min. |
| Final setting time | | 240min. |
| Compressive strength | 3days | 32.9N/mm$^2$ |
| | 7days | 41.5N/mm$^2$ |
| | 28days | 60.2N/mm$^2$ |
| Fineness (90µmsieve) | | 1.73% |
| Standard consistency | | 31.4% |

**Table 1 Properties of cement**

### b) Water

Preparation of specimens and curing done in locally available potable water.

### c) Fine aggregate

As per IS 383-1970, table4 sand used for experimental program was locally produced and was conforming zone II. The specific gravity of fine aggregate was found to be 2.629

| Gradation | Fall in Zone II |
|---|---|
| Fine modulus | 2.45 |
| Silt content | 0.78% |
| Specific Gravity | 2.629 |
| Moisture content | 1.4% |

**Table 2 Properties of Fine Aggregate**

**d) Coarse aggregate**

Locally available coarse aggregate passing from 20mm sieve and conforming IS 383-1970 were used in present work. The specific gravity of coarse aggregate was found to be 2.836.

| | |
|---|---|
| Aggregate Impact value | 12.4 |
| Aggregate Abrasion Value | 16.3 |
| Specific Gravity | 2.836 |
| Water Absorption | 1.06% |
| Combined Flakiness Index, Elongation Index | 22.9% |

**Table 3 Properties of Coarse aggregate**

**e) Silica Fume**

Silica fume, also called condensed silica fume or micro silica, is a finely divided residue resulting from the production of elemental silicon or ferro-silicon alloys that is carried from the furnace by the exhaust gases. It is collected from the flue gases from electric arc furnaces. Silica fume, with or without fly ash or slag, is often used to make high-strength concrete. Specific gravity of silica fume used in the project is 2.27

**f) GGBS**

Formally referred as Ground Granulated Blast-Furnace Slag (GGBS), is a glassy, granular material produced when molten iron blast-furnace slag is rapidly chilled - typically by water sprays or immersion in water - and subsequently ground to cement fineness. It is a non metallic manufactured by product from blast furnace created when iron ore is reduced to pig iron.The specific gravity of GGBS used in the project is 2.80

**g) FlyAsh**

Fly ash is one of the most commonly used pozzolana in concrete which is a by-product of thermal power generating stations. Commercially available fly ash is a finely separated residue that results from the combustion of pulverized coal and is conceded from the combustion chamber of the furnace by exhaust gases. It is normally categorized into two basic divisions namely Class-F and Class-C fly ash. Class-F fly ash is generally produced by burning anthracite or bituminous coal and has low calcium content. Class-C fly ash is usually produced by burning sub-bituminous coal and has cementitious and pozzolanic properties. The specific gravity of Fly Ash used in the project is 2.5 with fineness of 280 m2/kg.

**h) Super Palsticizer**

Uses of Super plasticizer allow the reduction of water to the point up to 30 per cent without decreasing workability in comparison to the possible reduction of up to 15 per cent in case of plasticizers. It is the use of Super plasticizer which has allowed the use w/c ratios as low as 0.25 or even lower and yet to make flowing concrete to achieve strength of the order 120 MPa or more. It is the use of Super plasticizer which has made it possible to use fly ash, slag and particularly silica fume to make high performance concrete. The Super plasticizers also produce a homogeneous, cohesive concrete usually without any tendency for segregation and bleeding.

## 2.1 Mix design

The mix was designed as per IS 10262:2009 for M30 grade concrete with 0.40 water cement ratio. Concrete mixes are prepared by partial replacement of cement by GGBS, Silica fume, Fly ash.

| Material | Specifications |
|---|---|
| Cement | 350 $kg/m^3$ |
| Water | 140 Litres |
| Fine Aggregates | 903$kg/m^3$ |
| Coarse Aggregates (20 mm) | 1150 $kg/m^3$ |
| Water Cement Ratio | 0.40 |

**Table 4 Mix Design M30**

| MIX | Cement (%) | Fly Ash (%) | GGBS (%) | SF (%) |
|---|---|---|---|---|
| A-0 | 100 | - | - | - |
| A-1 | 80 | 20 | - | - |
| A-2 | 60 | 20 | 15 | 5 |
| A-3 | 55 | 20 | 20 | 5 |
| A-4 | 50 | 20 | 25 | 5 |
| B-1 | 55 | 20 | 15 | 10 |
| B-2 | 50 | 20 | 20 | 10 |
| B-3 | 45 | 20 | 25 | 10 |
| C-1 | 50 | 20 | 15 | 15 |
| C-2 | 45 | 20 | 20 | 15 |
| C-3 | 40 | 20 | 25 | 15 |

**Table 5 Mix Type**

## 3 TEST SPECIMENS AND TEST PROCEDURE

Concrete mix proportion as per mix design M30 grade of concrete respectively. The 150mm x 150mm x 150mm size concrete cubes were used as test specimens to determine the compressive strength.

Various tests such as Slump Flow tests, L-box test , V-Funnel tests were carried out on fresh concrete in order to determine the workability properties of the mix.

| No. | Method | Unit | Typical Range of Value | |
|---|---|---|---|---|
| | | | Min. | Max. |
| 1 | Slump Flow By Abram's Cone | Mm | 600 | 800 |
| 2 | $T_{50}$ Slump Flow | Sec | 2 | 5 |
| 3 | V-Funnel | Sec | 6 | 12 |
| 4 | V-Funnel at $T_5$ Minutes | Sec | 0 | 3 |
| 5 | L-Box | $(H_2/H_1)$ | 0.8 | 1.0 |

**Table-6 Acceptance Criteria For Self Compacting Concrete(as per EFNARC guidelines)**

**Fig. 1 Slump Flow Test**

**Fig. 2 L-Box Test**


**Fig. 3 V-Funnel Test**

The above shown tests were performed on fresh concrete for analysis.

## 4 RESULTS

Various fresh properties considering specifications given by EFNARC guidelines such as Slump flow, V-funnel time, T-50 cm time and L-Box were checked for various mixes.

| Mix | Slump Flow (mm) | L- Box ($h_2/h_1$) | V-Funnel (Seconds) | T-50cm (Seconds) |
|---|---|---|---|---|
| A-0 | 620 | 0.8 | 10 | 6 |
| A-1 | 665 | 0.89 | 11 | 5 |
| A-2 | 643 | 0.9 | 10 | 5 |
| A-3 | 667 | 0.87 | 12 | 4 |
| A-4 | 674 | 0.93 | 9 | 4 |
| B-1 | 642 | 0.86 | 12 | 6 |
| B-2 | 659 | 0.9 | 11 | 5 |
| B-3 | 669 | 0.89 | 9 | 5 |
| C-1 | 631 | 0.83 | 13 | 5 |
| C-2 | 681 | 0.89 | 11 | 4 |
| C-3 | 684 | 0.93 | 10 | 4 |

**Table-7 Fresh Properties of SCC mixes.**

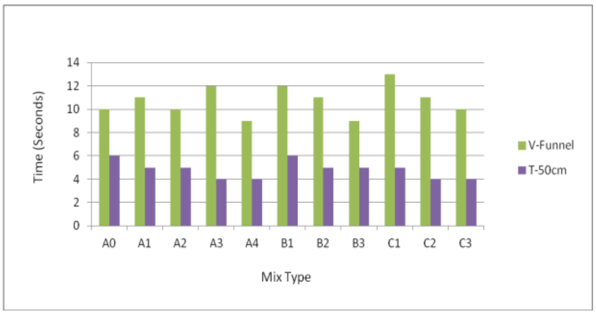


**Fig. 4 V-Funnel and T-50 Test Analysis**

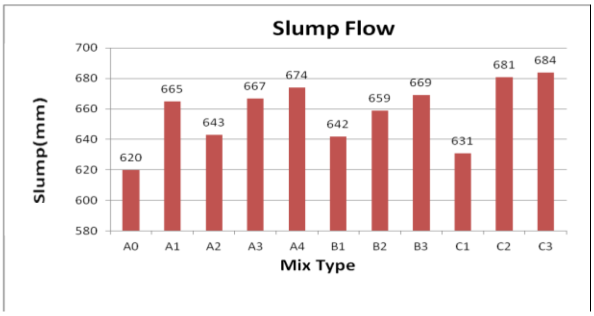


**Fig. 5 Slump Flow Test Analysis**

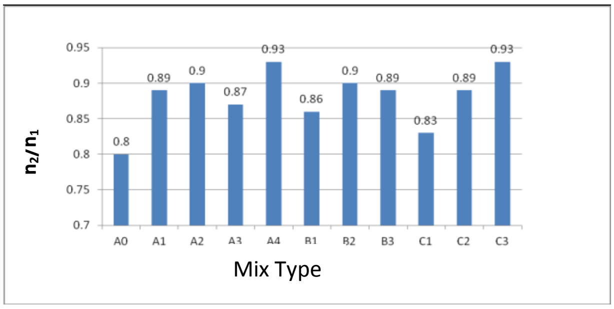


**Fig. 6 L-Box Test Analysis**

➢ **Compressive Strength**

| Mix | Avg. Comp. Strength | | |
|---|---|---|---|
| | 7 Days | 14 Days | 28 Days |
| A-0 | 21.63 | 29.99 | 36.15 |
| A-1 | 20.68 | 28.45 | 34.25 |
| A-2 | 20.83 | 26.99 | 33.66 |
| A-3 | 20.17 | 26.84 | 32.63 |
| A-4 | 19.58 | 24.49 | 29.55 |
| B-1 | 21.19 | 28.16 | 32.19 |
| B-2 | 20.75 | 25.96 | 30.65 |
| B-3 | 18.99 | 24.13 | 29.92 |
| C-1 | 20.09 | 24.86 | 30.36 |
| C-2 | 19.87 | 22.66 | 28.67 |
| C-3 | 17.45 | 21.49 | 26.91 |

**Table-8 Compressive Strength Test Results**

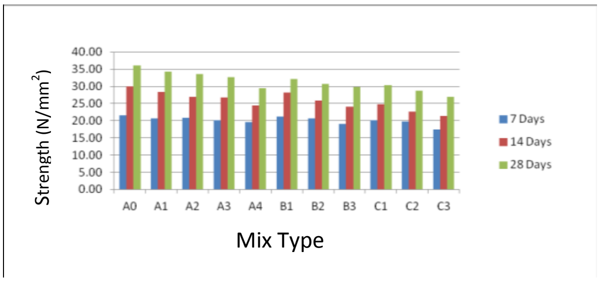


**Fig. 7 Compressive Strength Test Analysis**

## 5 CONCLUSION

- Sufficient slump flow is obtained for fresh concrete mix containing 1.5% super plasticizer.
- By increasing GGBS, the strength of concrete reduced.

- Also, increasing the amount of GGBS in the mix, the flow of fresh concrete increased giving satisfactory slump value.
- Increasing the Silica Fume content, the slump flow increased without affecting the final strength of the harden concrete specimen.
- The satisfactory results of fresh and harden concrete were obtained for the mix B-1 containing 20% Flyash, 15% GGBS and 10% Silica Fume.
- From the experiments conducted it can be observed that replacing higher cement content with admixtures and other cementitious materials , the constant reduction in strength is observed for harden concrete.

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## REFERENCES

i. N.Bouzoubaâa and M. Lachemib "Effect of Alccofine on Self Compacting Concrete" Cement and Concrete Research, Vol. 31, No. 3, Mar. 2001, pg.413-420.

ii. A.M.M Sheinn,C.T. Tam," Comparative Study on Hardened Properties of Self Compacting Concrete (SCC) with Normal Slump Concrete (NSC)" August 2004.

iii. Othmane Boukendakdji, El-Hadj Kadri, Said Kenai "Effects of granulated blast furnace slag and superplasticizer type on the fresh properties and compressive strength of self-compacting concrete" August 2011,583–590

iv. N.K. Amudhavalli, Jeena Mathew " Effect of silica fume on strength and durability parameters of concrete",Volume 3, Issue 1, pp: 28-35,August 2012

v. O¨zgu¨r C, akır *, O¨ mer O ¨ zkan Sofyanlı " Influence of silica fume on mechanical and physical properties of recycled aggregate concrete ,June 2014

vi. Truly Mittal, A. Borsaikia and S.Talukdar " Effect of silica fume on some Properties of concrete "

vii. EFNARC 2002 February. Specification and Guidelines for Self-Compacting concrete. EFNARC (European Federation of Producers and Applicators of Specialist Products for Structures).