International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 7, Issue 5, May 2017)

An Experimental Study on Self-Compacting Concrete by Partial Replacement of Cement with Silica Fumes and GGBS

Dr. M.Tholkapiyan[1], U. Ajith kumar[2]

[1]*Professor,* [2]*Bachelor of Engineering, Vel Tech High Tech Dr. Rangarajan Dr. Sakunthala Engineering College, Avadi, Chennai, Tamil Nadu*

***Abstract*—Self-compacting concrete (SCC) is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The hardened concrete is dense, homogeneous and has the same engineering properties and durability as traditional vibrated concrete.**

Due to industrialization there is huge amount of GGBS and Silica Fume created. These industrial wastes should be utilized in effective way by replacing cement by these waste products.

This paper focuses on the effects of Silica Fume and Ground Granular blast furnace slag (GGBS or GGBFS) when added as a partial replacement for cement.

The mix-design for SCC is arrived by modifying Krishna Murty. N mix design procedure for Self-compacting concrete as there is no definite procedure for calculating mix design of SCC. Workability of fresh concrete is determined by using tests such as: Slump flow, L-box, U-box tests

Keywords—Self-Compacting Concrete, Silica Fume, GGBS

I. INTRODUCTION

Self-Compacting concrete or Self-Consolidating concrete is a concrete mix which has a low yield stress, high deformability, good segregation resistance and moderate viscosity. Self-Compacting concrete is a flowing concrete mixture that is able to consolidate upon its own weight. The highly fluid nature of SCC makes it suitable for placing in difficult conditions and in sections 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.

In everyday terms, when poured, SCC is an extremely fluid mix with the following distinctive practical features - it flows very easily within and around the formwork, can flow through obstructions and around corners ("passing ability"), is close to self-leveling (although not actually self-leveling), does not require vibration or tamping after pouring, and follows the shape and surface texture of a mold (or form) very closely once set. As a result, pouring SCC is also much less labor-intensive compared to standard concrete mixes.

Once poured, SCC is usually similar to standard concrete in terms of its setting and curing time and strength. SCC does not use a high proportion of water to become fluid - in fact SCC may contain less water than standard concretes

II. OBJECTIVES

The objectives of the study are:

- To find the properties of the materials such as cement, sand, coarse aggregate, water etc.
- To obtain Mix proportions by considering properties of fresh concrete (according to EFNARC guidelines).
- To caste and cure the concrete specimens such as cubes, cylinders, and beams.
- To evaluate the mechanical characteristics of concrete such as compressive strength, split tensile test, flexural strength.
- To evaluate the results.

III. MATERIAL PROPERTIES

The materials used in this research are: 3.1 Cement Ordinary Portland cement of 53 grade was used in this investigation.

Table-1
Approximate Oxide Composition Limits of Ordinary Portland cement

Oxide	Percent content
Cao	60-67
Sio2	17-25
Al2o3	3.0-8.0
Fe2o3	0.5-6.0
Mgo	0.1-4.0
Alkalies	0.4-1.3
So3	1.3-3.0

The Details of Tests Conducted on Cement are Described Below.

S.No	Properties	Values
1	Specific Gravity	3
2	Fineness %(retained on sieve 90mirons	4%
3	Standard Consistency	36%
4	Initial setting time	64 mins
5	Final setting time	6hr 12 mins

3.2 Silica Fume

In this study, silica fume is brought from Ashwin Ceramics at chennai. Specific gravity of silica fume is 2.4

Table-3:
Properties of Typical Silica Fume

Constituents	Percentage
SiO2	90
Al2O3	0.4
Fe2O3	0.4
CaO	1.6
SO3	0.4
Na2O	0.5
K2O	2.2

Table-4:
Chemical and Physical Requirements as per European Committee for Standardization

SiO2	>85(%))
Loss On Ignition	<4(%)
Pozz. Activity Index-7days accelerated curing accelerated curing	>100(%)
Specific surface	>15 m2/gm&<35 m2/gm

3.3 GGBS

In this study, GGBS is brought from Astrra chemicals at chennai. Specific gravity of GGBS is 2.9 and its chemical composition is shown in table.

Table-5:
Approximate oxides compositions of GGBFS

Constituents	Percentage
CaO	63.00
SiO2	31.50
Al2O3	1.79
MgO	0.004
Mno2	0.48

3.4 Chemical Admixture

ADHERE MIX-700 naphthalene based super-plasticizer was used. It provides necessary workability. It is light Brown liquid.

3.5 Fine Aggregate

Aggregates smaller than 4.75mm and up to 0.075mm are considered as fine aggregatee

Table-6:
Properties of Fine Aggregate

S.No	Properties	Values
1	Specific Gravity	2.64
2	Water Absorption	3.1%
3	Fineness Modulus	2.513

SAND BELONGS TO ZONE – II and, it is Fine Sand as Fineness Modulus is less than 2.6.

3.6 Coarse Aggregate

Aggregates greater than 4.75mm are considered as coarse aggregate.

Table-7:
Properties of Fine Aggregate

S.No	Properties	Values
1	Specific Gravity	2.7
2	Water Absorption	0.8%
3	Fineness Modulus	6.58

3.7 Water

Water used for concrete and curing is free from harmful impurities.The pH value of water should be not less than 6.

IV. MIX DESIGN

- Designation of desired air content

Assumed as 2%

- Determination of coarse aggregate volume

DRUW = 1608 kg/m3
Specific Gravity = 2.66
% of Coarse aggregate = 48
Coarse aggregate weight = (1608*0.48)
= 771.84 Kg/m^3
Coarse aggregate volume =(771.84 /2.66)
=290.01654135 litre/m3

- Determination of Mortar volume

Mortar volume =Cement volume-Coarse aggregate volume
=1000-290.0165
= 709.8346 litre/m3

- Determination of Sand Volume

% of sand in Mortar volume = 45.30
Sand Volume = 709.8346*(45.30/100)
= 321.5551 litre/m3

- Determination of Paste volume

Paste Volume= Mortar volume-sand volume
= 709.8346-321.5551
= 388.2795 litre/m3

- Calculation of Paste composition

Specific gravity of cement : 3.15
Specific gravity of GGBS : 2.9
Specific gravity of SF: 2.62
Air content : 2% = 20 litre/m3
Water/ binder ratio (by weight) = 0.36
% of GGBS by weight of binder = 20
% of SF by weight of binder = 3
% of SP by weight of binder = 1
Binder = 550 kg/m3

International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 7, Issue 5, May 2017)

GGBS = 550*(20/100) = 110 kg/m3
SF = 550*(3/100)=16.5 kg/m3
SP = 550*(1/100)=5.5 kg/m3
Cement = 550-(110+16.5) = 423.5 kg/m3
Water = 550*0.35 = 192.5 litre/m3
Volume of cement = 423.5/3.15 = 134.44 litre/m3
Volume of GGBS = 110/2.9 = 37.93 litre/m3
Volume of SF = 16.5/2.62 = 6.29 litre/m3
Total Paste volume = Volume of (cement + GGBS +SF + Water +SP + Air) (423.5/3.15)+(37.93/2.44)+(16.5/2.3) +192.5+5.5+20 =371.82 litre/m3

- Calculation of constituent materials for concrete

% of absorption of 16mm : 0.3
% of absorption of sand : 1.0
% of moisture in 20mm : 0.0
% of moisture in 10mm : 0.0
% of moisture in sand : 0.0
% of dry material in SP : 40
Cement : 423.5 kg/m^3
GGBS : 110 kg/m^3
Initial water content : 185.4 litre/m^3
Coarse aggregate : 771.84 kg/m^3
Fine aggregate: 321.5551*2.6 = 836.043 kg/m^3
Adjusted water content
= Initial water - [CA*(% of moisture - % of absorption)/100] - [sand*(% of moisture - % of absorption)/100] - [SP*(100-%of dry material in SP)/100]
= 185.4 - [771.84 *(0-0.3)/100]-[836.043 *(0-1)/100]-[5.5*(100-40)/100]
=176.05 litre/m^3

V. TESTS FOR FRESH AND MECHANICAL PROPERTIES

5.1 Tests for fresh concrete properties:

5.1.1 Slump Cone Test

The slump flow test is done to assess the horizontal flow of concrete in the absence of obstructions. It is a most commonly used test and gives good assessment of filling ability. It can be used at site. The test also indicates the resistance to segregation.

5.1.2 L-Box Test

The test was developed in Japan.The test assesses the flow of concrete, and also the extent to which the concrete is subjected to blocking by reinforcement.

51.3 U-Box Test

The test was developed in Japan. The test is used to measure the filling ability of self-compacting concrete

5.2 Tests for Mechanical Properties

5.2.1 Compression Test

This test is done to determine the compressive strength ofconcrete specimens as per IS: 516- 1959.

It is done on 150mm cube. It is the most common test conducted on hardened concrete, partly because it is an easy test to perform, and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compression strength.

Table-8:
Specifications for fresh Property testing

SNO	METHOD	UNIT	TYPICAL RANGE OF VALUES	
			Minimum	Maximum
1	Slump flow by Abrams cone	mm	650	800
2	L-box	(h2/h1)	0.8	1
3	U-box	(h1-h2) mm	0	30

5.2.2 Split Tensile Test

This test is done to determine the Split-Tensile strength of concrete specimens as per IS: 516- 1959. The splitting test is carried out on a standard cylinder specimen of 150mm diameter and 300mm height by applying a line load along the vertical diameter. 5.2.3 Flexural Test This test is done to determine the Flexural strength of concrete specimens as per IS: 516- 1959. The Flexural strength test is carried out on standard beam specimens 150x150x750mm. The bed of the testing machine shall be provided with two steel rollers, 38 mm in diameter, on which the specimen is to be supported, and these rollers shall be so mounted that the distance from centre to centre is 60 cm for 15.0 cm specimens.

TABLE-9:
MIX PROPORTIONS

Mix	Cement	GGBS	SF	Fine agg	Coarse agg	w/c	SP 1%
Mix1 20% GGBS & 3%SF	423.5	110	16.5	836	771.8	0.35	5.5
Mix2 20% GGBS & 6%SF	407	110	33	836	771.8	0.35	5.5
Mix3 20% GGBS & 9%SF	390.5	110	49.5	836	771.8	0.35	5.5
Mix4 20% GGBS & 12%SF	374	110	66	836	771.8	0.35	5.5

International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 7, Issue 5, May 2017)

VI. RESULTS AND DISCUSSIONS

6.1 Fresh Properties

Table-10:
Test Results for Fresh Concrete

Mix	Flow Test Diameter in mm	L-Box(H_2/H_1)	U-Box(H_1-H_2) in mm
Mix-1	696	0.96	11
Mix-2	683	0.92	8
Mix-3	673	0.90	5
Mix-4	694	0.93	4
Mix-5	689	0.87	5
Mix-6	686	0.85	7
Mix-7	683	0.86	7

6.2 Mechanical Properties

Table-11:
Compressive Strength vs Different Mixes

S. NO	MIX DESIGNATION	COMPRESSIVE STRENGTH IN N/ mm2		
		7 day	14 day	28 day
1	MIX 1			
2	MIX 2			
3	MIX 3			
4	MIX 4			

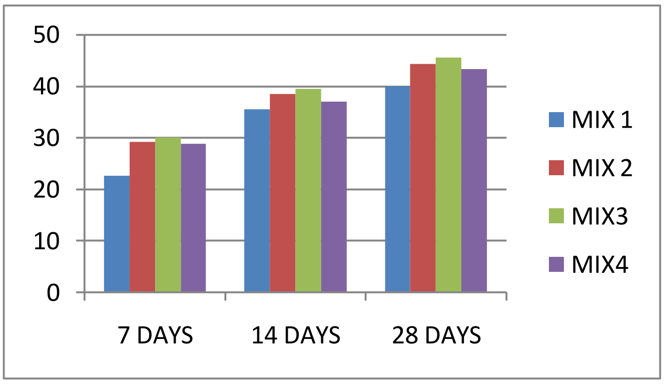
Table-12:
Split Tensile Strength vs Different Mixes

MIX	28 days
Mix 1	3.5
Mix 2	4.7
Mix 3	4.9
Mix 4	4.5

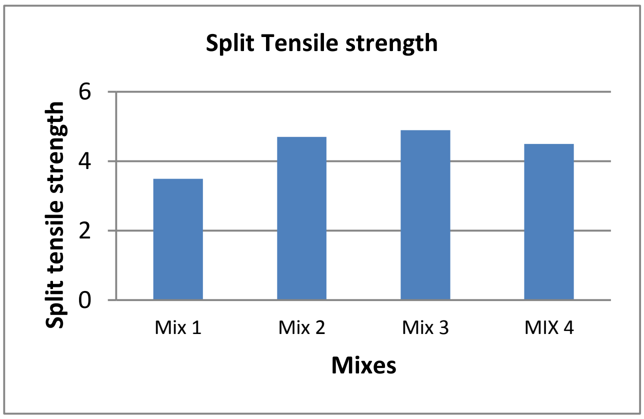
Table-13:
Flexural Strength of Concrete vs Different Mix

MIX	28 days
Mix 1	3.5
Mix 2	4.7
Mix 3	4.9
Mix 4	4.5

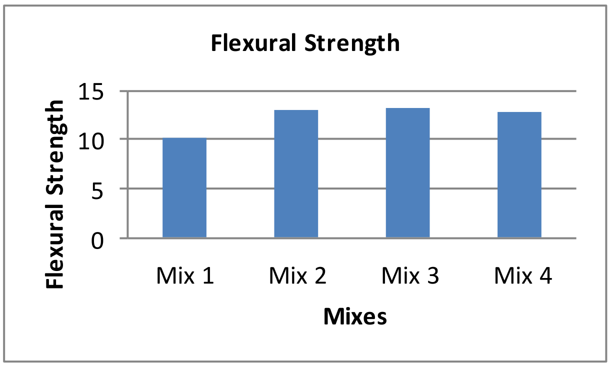
7.3Graphs



Graph-4: Compression Strength vs Different Mixes



Graph-5: Split Tensile Strength vs Different Mix



Graph-6: Flexural Strength vs Different Mixes

VII. CONCLUSION

The application of silica fume and GGBS in concrete mixture has significantly increasing and enhancing the properties of the concrete whether it is in wet stage or in harden condition. Form results it is clear that silica fume of 6% gives best results. And it is suggested that silica fume while using with GGBS not more than 6% is preferred to replace the cement. Rheological tests conducted were sufficient to ascertain whether the mix will have all the attributes of SCC or not. Silica fume provide mechanical strength to high performance self-compacting concrete by increasing the density. Addition of silica fumes developed filling and passing ability of concrete. From the results of mechanical properties, we know that the compressive strength has shown considerable increase from 7 days curing till 28 days of curing. Similarly flexural strength has increased at that same duration but not as much as the compressive strength of the concrete.In general, SSC with GGBS and silica fumes exhibits better performance in compression as compared to flexure. But setting time increase due to GGBS. Due to this temperature increases gradually, this leads to high strength. As the density and strength increases SSC have good resistance to temperature changes, chemical attacks as a result life span of the structure increases. It is best suitable for marine constructions where there are great chances of chlorine and sulphate attacks. The cost of SCC is higher than the conventional concrete, but it can be ignored by considering its performance.

REFERENCES

[1] EFNARC (2005), "Specification and Guidelines for Self Compact Concrete"

[2] Darshan H R, M.RameGowda "DEVELOPMENT AND STUDY OF BEHAVIOR OF SELF-COMPACTING CONCRETE USING GGBS"

[3] Salem Alsanusi "Influence of Silica Fume on the Properties of Self Compacting Concrete"

[4] J. M. Srishaila, Karthik Poovaiah D, K. N. Vishwanath, P. Prakash Development of High Strength Self Compacting Concrete Using Mineral And Chemical Admixture

[5] Aravinth S. N.Development of High Strength Self Compacting Concrete Using Mineral And Chemical Admixture

[6] BiswadeepBharali "EXPERIMENTAL STUDY ON SELF COMPACTING CONCRETE (SSC) USING GGBS AND FLY ASH"

[7] J. M.Srishaila1, Adarsh Uttarkar2, Prakash Parasivamurthy3,"VeenaJawali Influence of Fly Ash and Silica Fumes on the Behavior of Self Compacting Concrete"

[8] N. K. Amudhavalli, JeenaMathew "EFFECT OF SILICA FUME ON STRENGTH AND DURABILITY PARAMETERS OF CONCRETE"

[9] B.H.V. Pai, M. Nandy, A. Krishnamoorthy ,P.K.Sarkar C. PramukhGanapathyEXPERIMENTAL STUDY ON SELFCOMPACTING CONCRETE CONTAINING INDUSTRIAL BY-PRODUCTS

[10] A.A. Maghsoudi, Sh. Mohamadpour, M. MaghsoudiMIX DESIGN AND MECHANICAL PROPERTIES OF SELF COMPACTING LIGHTweight concrete

[11] N. K. Amudhavalli, JeenaMathew:"EFFECT OF SILICA FUME ON STRENGTH AND DURABILITY PARAMETERS OF CONCRETE"