Experimental Study On Strength Properties of Triple Blended Self Compacting Concrete

A.Uma, V.Murugesh

- *Uma Arumugam, currently pursuing masters degree program in Structural engineering in JCT College FO Engineering and Technology,Anna University, India,. E-mail: umaarumugama97@gmail.com*
- *V.Murugesh, Associate Professor,Structural Engineering Department in JCT College FO Engineering and Technology,Anna University, India*

Abstract— The evalution of concrete has lead to a wide range of research over the civil industry to produce highly efficient and high strength concrete. Hence the researches with the concrete has been made on a large scale and a number of concrete composite were introduced such as Geopolymer Concrete, Polymer Impregnated Concrete, Self Compacted Concrete,Fiber Reinforced Concrete, etc. In this article, we would study about the Triple Blended Self Compacting Concrete (SCC) , that composes of Silica Fumes, Ground Granulated Blast Furnace and Fly Ash, which strengthens the property of concrete. This type of SCC not oly enhances the strength but also reuses the waste materials from industries and ensures cleaner environment.

Index Terms— Triple blended, Fly Ash , Silica Fumes, Groung Granulated Blast Furnace, Self- Compacting

1 INTRODUCTION

REINFORCED concrete is one of the most versatile and widely used construction material. Thus enhancing the efficiency of the concrete would have a great impact on the widely used concrete fir its self compacting characteristics and additional strength benefits.Normally, concrete is heavily vibrated for flow into very intricate forms that posses a number of reinforcing bars. This could be overcome by the use of SCC that flows with ease into the formwork without blocking through the reinforcing bars without any heavy vibration.

The important part of Self Compacting Concrete is cement, which emits a lot of CO2 during production. It is mentioned that about 1.35 billion tons greenhouse gas is emitted annually from cement production. Thus, the use of industrial by-products is environmental friendly method of disposal. In this article a clear study on the Triple blended Self Compacting Concrete is made by replacing cement in 0%, 5%, 10%, 20%, and 30%in each mix of SCC, whereas silica fumes was replaced at constant percentage of 5% for all mixes along with Fly Ash and GGBS.

2 SELF- COMPACTING CONCRETE

2.1 Properties of Self-Compacting Concrete

The significant characteristics of Self Compacting Concrete arfe the properties in the fresh state.For efficient working of SCC its flow ability, fill ability, and resistance to segregation must be satisfied. These major properties of concrte are

discussed as follows,

2.2 Passing /Flow ability

- Self Compacting Concrete should flow under its own weight and fill all parts of formwork without any external aids or vibration.
- The deformability of SCC is characterized by the concrete fuildity and cohesion.
- This flow ability of SCC is tested by U-Box test and L-Box test.
- The excess paste that covers the surface area of aggregate serves to minimize the friction among the aggregates and give better flow ability.

2.3 Fill/ Passing Ability

- It is the ability of Self Compacting Concrete mix to pass through congested reinforcement without blocking, whist maintaining good suspension of coarse particle in the matrix, thus avoiding arching near obstacles and blockage during flow.
- This property is tested by means of slump flow test and V-funnel test.

2.4 Resistance to Segregation

- It is the ability to retain the coarse components of the mix and the fibre in suspension in order to maintain a homogeneous material.
- Segregation is resisted by using super-plasticizers.
- This property is tested by V-funnel test and V-funnel at T5 minutes.

3 BENEFITS OF SELF COMPACTING CONCRETE

Self compacting Concretereduces the process and the cost of vibration. It improves thedurability and reliability of concrete structures. SCC improves the quality of concrete and reduces the cost of on site repair and overall cost. It imparts better surface finish. Ensures the ease of placement and results in reduction in labor requirement.

4 LIMITATIONS OF SELF COMPACTING CONCRETE

- Self compacting concrete unlike the conventional concrete is highly reactive when subjected to any slight variation in

its property.

- An uncontrolled variation of even 1% moisture content in fine aggregate will have a much bigger impact on the rheology of SCC at very low water-cement ratio.
- Though efficient, self compacting concrete are costlier than conventional concrete, since they have high dosages of chemical admixtures.

5 MATERIALS PROPERTIES

The materials used in this study are Fly Ash , Silica Fumes, GGBS, cement, fine aggregate, coarse aggregate and super plasticizers.

5.1 Fly Ash

Fly ash also known as pulverized fuel ash is a coal combustion product that is composed of the particulates that are driven out of coal fired boilers together with fuel gases. Because of its pozzolanic properties, fly ash can be used as a partial replacement of Portland cement in SCC. Both the fresh and hardened properties of the concrete can be improved by using Fly Ash. Upto30% of replacement of Fly Ash by mass of cement increases the strength of SCC.Due to its small spherical shape, adding Fly Ash to SCC mix can improve its workability while reducing water demand. Fly ash increases the reactivity of SSCC, leading to increased compressive strength, improved durability and reduced drying and autogenous shrinkage.

Table 5.1-Physical Properties of Fly Ash

S. No	Property	Result
1	Colour	Grey
2	Specific gravity	2.13

Table 5.2-Chemical Properties of Fly Ash

S. No	Content	Percentage %
1	SiO_2+Al_2O_3+Fe_2O_3	90.5
2	SiO_2	58
3	CaO	3.6
4	SO_3	1.8
5	Na_2O	2
6	L.O.I	2
7	MgO	1.91

5.2 GROUND GRANULATED BLAST-FIRNACE SLAG

Groung granulated blast furnace slag also referred to as “slag” is a by product from the blast furnace used to make iron. Addition of GGBS to SCC increases its compactability, workability and retains it for a long time, while protecting cement against both sulphate () and chloride attack. Water demand tends to be less for concrete made with GGBs, owing to its smooth surface texture of slag particles compared to cement and delay in chemical reactio. GGBS replacement contributes to environmental protection as it minimizes the use of cement during the production of concrete.

Table 5.3 -Physical properties of GGBS

S. No	Property	Result
1	Colour	Dull white
2	Fineness (m/kg)	390
3	Specific gravity	2.85

Table 5.4-Chemical properties of GGBS

S. No	Content	Percentage %
1	Magnesia	7.73
2	Sulphide Sulphur	0.50
3	Sulphite	0.38
4	Loss Of Ignition	0.26
5	Manganese	0.12
6	Chloride	0.009
7	Glass	91
8	Moisture Content	0.10

5.3 SILICA FUMES

Silica fumes also referred to as micro silica are nothing but by-products extracted from the exhaust gases of ferrosilicon, silicon and other metal alloy smelting furnaces. Silica fumes consistes of amorphous silicon dioxide(SiO2), when added to Portland cement concrete it improves its compressive strength, bond strength and abrasion resistance. As the particles size ofSilica fumes is very very fine, a large surface area and high SiO2 content, it is very reactive pozzolanic when used in concrete. Silica fumes reacts with CH (whch is released by Portland cement in chemical reaction) to form additional binder material called Silicate Hydrate (C-S-H) which is very similar to C-S-H formed from Portland cement and water and therefore reduces CH content.

Table5.5- Physical properties of Silica Fume

S. No	Property	Result
1	Colour	Grey
2	Specific gravity	2.2

Table 5.6-Chemical properties of Silica Fume

S. No	Content	Percentage %
1	SiO2	90.20
2	Al_2O_3	0.82
3	Fe_2O_3	1.67

4	CaO	1.27
5	SO_3	1.40
6	K_2O	4.02
7	L O I	2.4

5.5 Cement

Concrete produced from Portland cement is one of thr most versatile constyruction material. For this study ordinary Portland cement of 53 grade was used. The test results are the properties of cement used as stated below,

Table5.7- Physical Properties of Cement

S. No	Property	Result
1	Specific gravity	3.15
2	Normal consistency	36%
3	Initial setting time	35min
4	Final setting time	600min

5.6 Fine Aggregate

The fine aggregate used is l;ocally available natural sand. This sand was subjected to sieve analysis and all the pebbles in it were removed. Sand passing through IS 4.75mm sieve was used.

Table 5.8-Physical Properties of Fine Aggregate

S. No	Property	Result
1	Specific gravity	2.68
2	Surface texture	smooth
3	Fineness modulus	4.3

5.7 Coarse Aggregate

The aggregate size limited to 20mm was used. The aggregate serves as reinforcement to add strength to the overqll composition. The test results confines to
IS 383-1970(Part III) recommendations.

Table 5.9-Physical properties of coarse aggregate

S. No	Property	Result
1	Specific Gravity	2.8
2	Fineness Modulus	6.4
3	Particle Shape	Angular

5.8 Super plasticizers

To provide necessary workability of Self compacting concrete an essential component, super plasticizer are used. In this CONPLAST SP 430 was used.

6 Methodology

This experimental investigation is carried out to study the properties of the Self Compacting Concrete when blended with silica fumes, fly ash, and GGBS at various percentage of replacement with cement. Initially the materials are collected and tested for the properties to codal specifications and the mix is designed for percentage replacements of 5%, 10%, 20%, and 30%. The moulds are tested at intervals of 7,14 and 28 days. Finally, the moulds are analyzed and tested for their properties such as compressive strength, split tensile strength, and flextural strength. The results are analyzed and tabulated.

7 Mix design

The mix design is done as per Nan-Su mix design methods for Self Compacting Concrete for M30 grade of concrete. Mix ratio of SCC for M30.

8 Fresh properties of concrete

TEST RESULTS

The test results for the fresh properties of the concrete for slump flow,T50 slump flow in seconds, U-Box test and V-Funnel test and L-Box test were conducted and the results are stated below.

TEST METHODS	SCC 1	SCC 2	SCC 3	SCC 4	SCC 5
Slump flow mm	655	660	680	670	650
T_{50} cm Slump flow Sec	3.6	4.4	4	4.5	4.7
V – funnel test Sec	6	6.2	6.4	7.2	10.6
V – funnel test at T_5 min Sec	2.2	2.3	2.4	2.8	3
U – box test mm	20	25	22	26	30
L – box test mm	0.92	0.90	0.91	0.87	0.85

All the mixes of triple blended SCC with 0, 15%, 25%, 45% and 65% replacement of cement by fly ash, GGBS and silica fume satisfied the requirements of the limiting values for Self Compacting Concrete as per EFNARC acceptance criteria.

From table 7.1 it is observed that using higher percentages of fly ash, GGBS, silica fume as replacement of cement in SCC reduces the workability of SCC. The mix SCC 3 with 10% fly ash, 10%GGBS and 5% silica fume as replacement of cement showed remarkable workability when compared to other mixes.

9 Hardened properties of concrete

The test for hardened properties of concrete are obtained from compressive strength test, split tensile test, and flextural strength testand the results for various mixes of triple blended Self compacting Concrete with 0%, 15%, 25%, 45%, and 65% replacement of cement by flyash, GGBS, and silica fumes is given below.

COMPRESSIVE STRENGTH FOR 7, 14 and 28 DAYS

Table 9.1: Compressive Strength for 7, 14 and 28 days

MIX	7 day (MPa)	14 day(MPa)	28 day(MPa)
SCC 1	19.38	22.83	30.22
SCC2	21.05	27.13	34.76
SCC3	24.54	30.11	39.17
SCC4	22.35	26.72	37.40
SCC 5	18.44	24.56	33.56

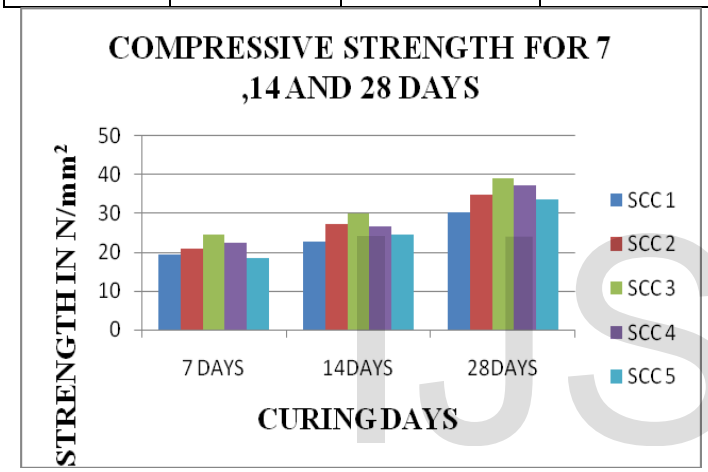

Figure 9.1: compressive strength for 7, 14 and 28 days.

TENSILE STRENGTH FOR 7, 14 and 28 DAYS

Table 9.2: Tensile Strength for 7,14and 28 days

MIX	7 day (MPa)	14 day(MPa)	28 day(MPa)
SCC 1	1.92	2.75	3.20
SCC2	2.19	2.87	3.48
SCC3	2.44	3.30	3.82
SCC4	2.16	2.71	3.37
SCC 5	1.88	2.50	3.03

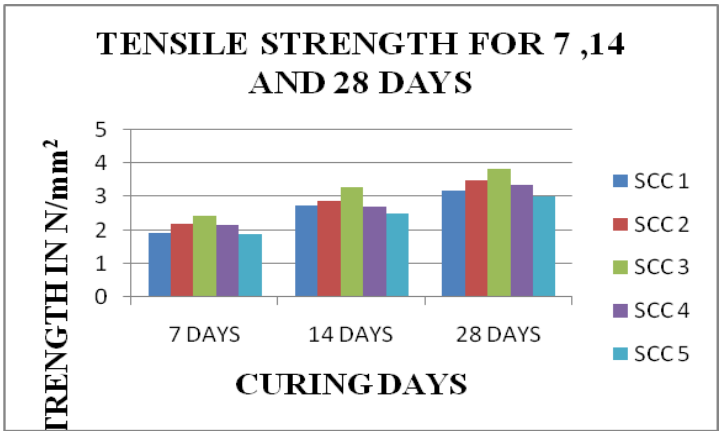

Figure 9.2: Tensile Strength for 7,14and 28 days

FLEXURAL STRENGTH FOR 28 DAYS

Table9.3: Flexural Strength for 28 days

MIX	PRISM I (MPa)	PRISM II (MPa)	AVERAGE (MPa)
SCC 1	4.52	4.44	4.48
SCC2	4.75	4.64	4.69
SCC3	5.07	4.95	5.01
SCC4	4.68	4.73	4.70
SCC 5	4.24	4.32	4.28

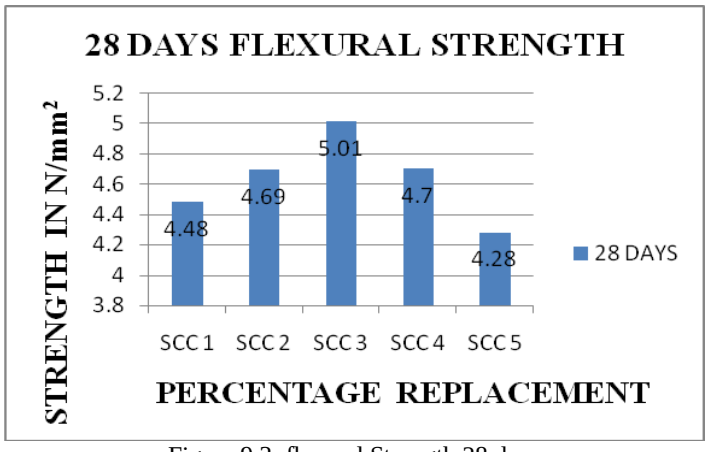

Figure 9.3: flexural Strength 28 days

10 CONCLUSION

From the experimental investigation on triple blended Self Compact-

ing Concrete it was concluded that,

The properties of the concrete such as compressive strength, flextural strength and split tensile strength has increased upto upto 25% replacement of cement by 10% Fly Ash,10% Ground Granulated Blast Slag and 5% Silica Fumes. Replacement higher than 10% Fly Ash, GGBS and 5% Silica Fumes in cement resulted in decrease in strength characteristics and workability. The workability of concrete has been increased with the replacement of Fly Ash, Silica Fumes and GGBS in place of cement and satisfies the acceptance criteria of Self Compacting Concrete.

ACKNOWLEDGMENT

The authors wish to thank the authorities of JCT College Of Engineering And Technology, Coimbatore, for the help rendered for conducting this experimental investigation.

REFERENCES

[1] Specification and Guidelines for Self Compacting Concrete,(2002) EFNARC

[2] ISBN 0953973344.

[3] B.H.V. Pai, M. Nandy, A. Krishnamoorthy, P.K.Sarkar ,C. Pramukh Ganapathy,(2014) 'Experimental Study on Self compacting Concrete containing Industrial By-Products' European Scientific Journal edition vol.10, No.12 ISSN: 1857 – 7881 (Print) e - ISSN 1857- 7431.

[4] S. Mahesh (2014) 'Self Compacting Concrete and Its Properties' International Journal of Engineering Research and Applications ISSN: 2248-9622, Vol. 4, Issue 8 (Version 7), pp.72-80.

[5] T.Jeevetha, S.Krishnamoorthi, G.S.Rampradheep (2014) 'Study on Strength Properties of Self-Compacting Concrete with Micro Silica' International Journal of Innovative Research in Science, Engineering and Technology Vol. 3, Issue 4, April 2014 ISSN: 2319-8753.

[6] Ankit J. Patel , Dixitkumar D. Patel, Dhruvkumar H. Patel, Vivek A. Patva (2014) 'Self-Compacting Concrete with use of waste material' International Journal For Technological Research In Engineering Volume 1, Issue 9, May-2014 ISSN (Online): 2347 – 4718.

[7] Heba A. Mohamed (2011) 'Effect of fly ash and silica fume on compressive strength of self-compacting concrete under different curing conditions' Ain Shams Engineering Journal, 79–86.

[8] U. N. Shah, Dr C. D. Modhera (2014) 'Process Fly Ash effect on harden properties of Self Compacting Concrete' International Journal of Engineering, Business and Enterprise Applications, pp. 145-148 ISSN (Online): 2279-0039

[9] N. Bouzouba and M. Lachemi (2001) 'Self Compacting Concrete Incorporating High-Volumes of Class F Fly Ash: Preliminary Results' Cement and Concrete Research, Vol. 31, No. 3, pp. 413-420.

[10] M. Adams Joe, A. Maria Rajesh(2015) 'Study on the Effect of Ggbs & M Sand in Self Compacting Concrete' The International Journal Of Engineering And Science (IJES) Volume 4 Issue 8 Pages PP -12-18 ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805.

[11] Pradyna P Urade ,Chandrakanth U Mehetre and Shiram H Mahure(2014) 'Comparative Study of Properties of Self Compacting Concrete with Ground Granulated Blast Furnace Slag and Fly Ash as Admixtures ' International Journal of Civil , Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD) ISSN(P): 2249-6866; ISSN(E): 2249-7978 Vol . 4, Issue 2, 127-138

[12] Nan Su , Buquan Miao(2003) 'A new method for the mix design of medium strength flowing concrete with low cement content' Cement & Concrete Composites 215–222.

[13] IS 2386 -1963 part I to VIII, Indian Standard Methods of test for Aggregate Concrete. Bureau of Indian Standards, New Delhi.

[14] IS 383:1970 ' Specification for coarse and fine aggregate from natural sources for concrete 'Bureau of Indian standards, New Delhi, India.

[15] IS 456-2000, plain and reinforced concrete code of practice.