Asian Journal of Engineering and Applied Technology
ISSN: 2249-068X Vol. 5 No. 2, 2016, pp.15-21

Experimental Research on Triple Blended Self-Compacting Geo Polymer Concrete

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Abstract - **Self-compacting concrete (SCC) represents one of the most outstanding advances in concrete technology during the last decade. self compacting concrete is a flowing concrete mixture that is able to consolidate under its own weight. The highly fluid nature of SCC makes its suitable for placing in difficult situation and in sections with congested reinforcement. The aim of the study is to make use of Fly Ash, Ground Granulated Blast Furnace Slag and Silica Fume as replacements of cement and understand its effect on the fresh properties and hardened properties of concrete. The investigation includes the concept of triple blending of Fly ash, GGBS and Silica Fume, this triple blend exploits the beneficial characteristics of Pozzolanic materials in producing a better concrete.**
Keywords: Triple Blended, Srlf-Campacting, Geo Polymer

I. INTRODUCTION

Concrete is the most basic element of for any kind of construction work. No matter what type of building structure it is, the concrete should be sturdy and well compacted. Proper compaction results in additional strength to the structure but also good finish and appearance to the final product. Unlike the conventional concrete SCC đesn't require compacting using external forces from mechanical equipments, instead SCC is designed in such a way that it gets compacted using its own weight and characteristics. The most important part of self compacting concrete is cement .The production process of this raw material produces a lot of carbon dioxide. It is well known that the CO2 emission initiates harmful environmental changes. The most effective way is to decrease the CO2 emission of cement industry is to substitute a proportion of cement with other materials. The supplementary cementing materials such as Fly Ash, Ground Granulated Blast Furnace Slag and Silica Fume, Met kaolin can be used as replacement of cement. The use of these industrial by product is an environmental friendly method of disposal of large quantities of materials that would otherwise pollute land, waste and air. In the present study a triple blended self compacting concrete is made by using replacement of cement in 0 %, 15%, 25%, 45% and 65% by Fly Ash, Ground Granulated Blast Furnace Slag and Silica Fume. Fly ash and GGBS was used equally in percentages of 5 %, 10% 20% and 30% in each mix of SCC. While silica fume was added in a constant percentage of 5% for all the mixes together with Fly ash and GGBS as replacement for cement.

Characteristic of SCC

The main characteristics of SCC are the properties in the fresh state. In order to flow, fill through the dense reinforcement the SCC must pose certain properties like

1) Passing ability
2) Filling ability
3) Resistance to Segregation

The passing ability of SCC is to flow through tight openings such as spaces between steel reinforcing bars without segregation or blocking. The filling ability of SCC to flow into and fill completely all spaces within the formwork, under its own weight. The resistance to segregation is to maintain its stability under high flow conditions i.e. it should not segregate and should remain homogenous in composition during transport and homogeneity.

Advantages of SCC

Faster construction times. Easier placing and better surface finish. Greater freedom in design. Improved durability and reliability of concrete structures. Ease of placement results in cost savings through reduced equipment and labour requirement. Improved quality of concrete and reduction of onsite repairs and overall cost. Possibilities for utilization of dusts which are currently waste products and which are costly to dispose of.

Fly Ash

Fly ash is one of the residues generated in the combustion of coal. Fly ash is generally captured from the chimneys of coal fired power plants. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2) and calcium oxide (CaO). Fly ash results in reduction of water demand, bleeding, drying shrinkage, also reduces heat of hydration due to less reactivity and also reduces alkali aggregate reaction and segregation in concrete. Fly ash use creates significant benefits for our environment. Fly ash use conserves natural resources and avoids landfill disposal of ash products

Ground Granulated Blast Furnace Slag (GGBS)

GGBS is obtained by quenching molten iron slag from a blast furnace in water or steam to produce glassy, granular product that is then dried and ground into fine powder. The replacement of cement with GGBS reduces the unit water content needed for the concrete and thereby increasing the durability of the structure. It also reduces the temperature rise and helps to avoid early age cracking, improved workability, increased resistance to chemical attack and corrosion resistant.

Silica Flume

Silica fume (SF) is a by-product resulting from the reduction of high-purity quartz with coal in electric arc furnaces in the manufacture of ferrosilicon alloys and silicon metal. Silica fume decreases the permeability, thereby increasing the resistance of concrete against corrosion, improving its strength and durability. Because of its extreme fineness and high silica content it is very effective. Pozzolanic material. Because of the high surface area of silica fume it reduces the mobility of water within the concrete and thereby eliminating bleeding and segregation.

II. LITERATURE REVIEW

S. Mahesh (2014) investigated about the self compacting concrete and its properties by replacing the cement content in levels of 10%, 20%, 30%, 40% and 50% by fly ash. In the study it has been found that with increase in the super plasticizers dosage the workability was increased thus the required slump value fulfilling the criteria of EFNARC was obtained. For 30% fly ash replacement the fresh properties were good as compared to other mixes. A replacement of 30% was obtained as the optimum consideration for flow abilities, mechanical properties and durability of SCC. The acid resistance of SCC with fly ash was higher when compared with concrete mixes without fly ash at the age of 28, 56 and 90 days.

T. Jeevetha and Dr S. Krishnamurthy (2014) studied about the strength properties of self compacting concrete with micro silica Cement was replaced with micro silica in 5% an 10%.The workability of mix was evaluated by the workability test such as slump flow test ,V funnel test, L box test .From the workability test it was seen that the workability decreases with increase in percentage of micro silica .It was concluded that at 5% replacement of micro silica the mix shows good workability and compressive strength .With further increase in replacement percentage the compressive strength decreases gradually.

Ankit J Patel et al (2014) investigated about the properties of self compacting concrete with the use of waste material. The study made use of ground granulated blast furnace slag as a replacement of cement in 9% , 14%,18% and understand its effect on fresh properties ,compressive strength of SCC. It was concluded GGBS replacement can have a better workable concrete and also been verified that by using slump flow, T 50cm slump flow, J ring test ,L box test and U box test that the self compacting concrete achieved consistency and self compatibility under its own weight, without any external compaction.SCC with GGBS exhibited satisfactory results in workability because of small particle size and more surface area. The test result indicated that 9% by mass replacement of GGBS for cement gives the highest strength for short and long terms and when GGBS is replaced by 14% and 18% the strength decreases.

U .N Shah and Dr. C.D Modhera (2014) concluded from the study on process fly ash effect on hardened properties of self compacting concrete that the reduction in compressive strength as the fly ash percentage got increased. Study show that the strength reductions from 50 Mpa to 25 Mpa for fly ash replacement of 30 to 70 percentages at the age of 28 days. It was also observed that the spilt tensile strength of SCC got reduced as the fly ash percentage increased. About 60% spilt tensile strength got reduced at the age of 28 days. Study shows the strength reduction from 3.89Mpa to 2.39Mpa for the fly Ash replacement of 30 percentages to 70 percentages at the age.

Pradnya P.Urade et al (2014) made a comparative study of properties of self compacting concrete with ground granulated blast furnace slag and fly ash as admixtures. The effect of use of above mineral admixture fines on fresh properties of SCC was studied. The cement was replaced in 10%, 20% and 30% by GGBS and fly ash. A suitable and appropriate chemical admixture i.e. super plasticizer was used. It has been reported that economically competitive SCC can be produced by replacing up to 50% of OPC with GGBFS & fly Ash. As long as the correct proportions are used when replacing Ordinary Portland Cement with GGBFS & Fly Ash the durability of the structure will be enhanced, leading to a longer life for the concrete. The addition of 10 %, GGBFS and Fly Ash in SCC mixes increases the self compact ability characteristic like filling ability, passing ability, flowing ability and segregation resistance. And it can also be seen that compressive strength, flexural strength and split tensile strength is maximum for 10% replacement as compared to 20% and 30 %.

Heba A Mohamed (2011) investigated about the effect of fly ash and silica fume on the compressive strength of self compacting concrete under different curing condition. The work involved three types of mixes the first consisted of different percentages of fly ash (FA), the second uses different percentages of silica fume(SF) and the third uses a mixture of FA and SF. The results were obtained as higher the percentage of FA the higher the values of concrete compressive strength until 30% of FA. However the highest value of

concrete compressive strength is obtained from mix containing 15% SF. The highest value of compressive strength for all the test cases is obtained from specimens cured in water for 28 days and lowest value is obtained from air cured specimens.SCC with 10% FA and 10% SF gave the highest value of compressive strength for SCC consisted of combination.

Nan Su and Buquan Miao(2003) He has proposed a new mix design method for medium strength flowing concrete (FC) with low cement content. The proposed method determines the packing factor (aggregate content) first and then fills binding paste containing the fly ash and GGBS into the voids between the aggregate to make concrete that has desired workability and strength. Test on slump, slump flow and compressive strength were carried out and the result indicate that medium strength FC can be produced successfully using this method. Concrete mixtures designed by using this proposed method require a small quantity of binder and is therefore very economical of FA and SF.

III. METHODOLOGY

COLLECTION OF MATERIALS

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TEXTING OF MATERIALS

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MIX DESIGN

⇩

MIXING WITH SPECIFIC PROPORTION

⇩

MOULDING OF SPECIMEN

⇩

DEMOULDING OF SPECIMEN

⇩

CURING FOE 7,14&28 DAYS

⇩

TESTING OF SPECIMEN

⇩

IV. RESULT ANALYSIS AND CONCLUSION

Materials Used

The different materials used in this investigation are

1. Cement
2. Fine aggregate
3. Coarse aggregate
4. Fly Ash
5. Ground Granulated Blast Furnace Slag
6. Silica Fume
7. Chemical admixtures: Super plasticizer (Conplast SP430)
8. Portable Water

Cement

For this study Ordinary Portland Cement of 53 Grade was used. The eimportant properties of this cement have been tested and given below:

TABLE I THE IMPORTANT PROPERTIES OF THE CEMENT

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

Fine Aggregae

Locally available river sand confined grading zone II of IS: 383-1970 is used. Generally fines are classified based on size, i.e.; below 4.75mm is regarded as fine aggregate.

TABLE 2 FINE AGGREGAE

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

Coarse Aggregate

Coarse aggregate of nominal size of 20mm is chosen for the study.

TABLE 3 COARSE AGGREGATE

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

Fly Ash

Fly ash is a very grey powder obtained after burning a coal. The combustion of powder coal in thermal power plant produces fly ash.

TABLE 4 THE PHYSICAL PROPERTIES OF FLY ASH

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

TABLE 5 THE CHEMICAL COMPOSITION 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	MgO	1.91
7	L.O.I	2

Ground Granulated Blasted Furnace Slag

Ground granulated blast furnace slag is a non-metallic powder consisting of silicates and aluminates calcium and other bases.

TABLE 6 THE PHYSICAL PROPERTIES OF GGBS

	Property	Result
1	Colour	Dull white
2	Fineness (m/kg)	390
3	Specific gravity	2.85

TABLE 7 THE CHEMICAL COMPOSITION OF GGBS

S. No.	Content	Percentage %
1	CaO + MgO +SiO_2	76.03
2	Magnesia	7.73
3	Sulphide Sulphur	0.50
4	Sulphite	0.38
5	Loss Of Ignition	0.26
6	Manganese	0.12
7	Chloride	0.009
8	Glass	91
9	Moisture Content	0.10

Silica Flume

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.

TABLE 8 THE PHYSICAL PROPERTIES OF SILICA FUME

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

TABLE 9 THE CHEMICAL COMPOSITION OF SILICA FUME

S. No.	Content	Percentage %
1	SiO_2	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

Super Plasticizer

The most important admixtures are the Super plasticizers (high range water reducers), Super plasticizers are essential components of SCC to provide necessary workability. CONPLAST SP 430 is used as super plasticizer.

Mix Design

The mix design is done as per the IS mix design method for self compacting concrete for M30 grade concrete.

0.34 :	1:	1.77 :	1.38 :	0.016
W	C	FA	CA	CP-sp430

TABLE 10 THE QUANTITIES OF MATERIAL NEEDED FOR $1M^3$ OF SCC MIX (UNIT KG/M^3)

Mix	Coarse Aggregate	Fine Aggregate	Cement	Fly Ash	GGBS	Silica Fume	Water	SP
SCC 1	736	941	530	-	-	-	180	9
SCC 2	736	941	450	26.5(5%)	26.5(5%)	26.5(5%)	180	9
SCC 3	736	941	397.5	53(10%)	53(10%)	26.5(5%)	180	9
SCC 4	736	941	291.5	106(20%)	106(20%)	26.5(5%)	180	9
SCC 5	736	941	185.5	159(30%)	159(30%)	26.5(5%)	180	9

TABLE 11 MIX AND % OF FLY ASH

MIX	% FLY ASH	FUME
SCC 3	- 10% FLY ASH, 10% GGBS,	5% SILICA FUME
SCC 4	- 20% FLY ASH, 20% GGBS,	5% SILICA FUME
SCC 5	- 30% FLY ASH, 30% GGBS,	5% SILICA FUME

V. TEST RESULTS FOR FRESH EARTH PROPERTIES

The fresh properties tests such as slump flow test, T_{50} slump flow in sec, U box test and V- funnel test and L box test are conducted. 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.

TABLE 12 THE VALUES OF THE TEST RESULTS

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

TABLE 13 COMPREHENSIVE STRENGTH FOR 7, 14 AND 28DAYS

MIX	7 day	14 day(MPa)	28
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

TEBLE 14 TEST RESULT FOR TENSILE STRENGTH

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

Tensile strength for 7,14 and 28 days

TABLE 15 TEST RESULT FOR FLEXURAL STRENGTH

MIX	28 DAYS (MPa)
SCC 1	4.48
SCC2	4.69
SCC3	5.01
SCC4	4.70
SCC 5	4.28

Flexural strength for 7, 14 and 28

VI. CONCLUSION

From experimental study conducted on Triple blended self compacting concrete it is concluded that: The workability of concrete has been increased with the addition of Fly Ash, Ground Granulated Blast Furnace Slag and Silica Fume as a replacement of cement and it satisfied the acceptance criteria for self compacting concrete, also the addition of super plasticizers made the concrete more workable. The compressive strength, flexural strength and split tensile strength have been increased upto 25% replacement of cement by 10% Fly ash, 10% GGBS and 5% silica fume Beyond the replacement of 10%. Fly Ash, GGBS and 5% Silica Fume in cement resulted in decrease of strength characteristics and workability. Triple blended self compacting concrete reduces amount of cement content and make use of industrial by products. There by reduces the environmental pollution and remains as an eco friendly concrete.

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