International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in; editorijoer@gmail.com

Vol.7., Issue.3, 2019
May-June

RESEARCH ARTICLE

ISSN: 2321-7758

EXPERIMENTAL INVESTIGATION ON STRENGTH PROPERTIES OF SELF COMPACTING CONCRETE BY PARTIAL REPLACEMENT OF FLY ASH AND GGBS

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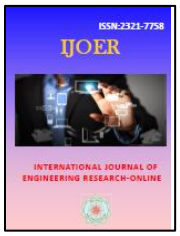
Doi: https://doi.org/10.33329/ijoer.72.43



ABSTRACT

Self-compacting concrete is a fluid mixture suitable for placing in structures with congested reinforcement without vibration. Self-compacting concrete development should guarantee an honest balance between deformability and stability. Also, compatibility is stricken by the characteristics of materials and also the combine proportions; it becomes necessary to evolve a procedure for combine style of SCC. The paper presents associate degree procedure for the planning of self- compacting concrete mixes. The check results for acceptance characteristics of self-compacting concrete like slump flow, V-funnel and L-Box are presented. Further, compressive strength at the ages of 28, 56, and 90 days was also determined and results are included here.

Key Words: Acid Resistance Test, Alkalinity Test, Combine Design, Compressive Strength, Fly Ash, Ground Granulated Blast Furnace Slag, Hardened Concrete Properties, Rapid Chloride Permeability Test (RCPT), Sulphate Attack Test, Self-Compacting Concrete.

1. INTRODUCTION

Utilization of waste materials and by-products may be a partial answer to environmental and ecological issues. It helps in reducing the price of cement and concrete producing, but also numerous indirect benefits such as reduction in landfill cost, saving in energy, and protecting the environment from possible pollution effects. Further, their utilization may improve the micro structure, mechanical and durability properties of mortar and concrete, which are difficult to achieve by the use of only OPC. Self-compacting concrete (SCC) also referred to as "self-consolidating concrete," has newly been one of the most important development in the construction industry. SCC, require no compaction energy and use of vibrators inside entirely filling the formwork yet in the attendance of dense reinforcement has been developed in Japan in the late 1980s, to improve the reliability of concrete and concrete structures

The hardened SCC is dense, homogeneous, and has better engineering and mechanical properties than traditional vibrated concrete. Though, to design a proper Self-Compacting Concrete mixture is not a easy chore. Recent appliance of self-compacting concrete (SCC) is determined on high performance; improved and new consistent excellence, thick and consistent surface texture, improved durability, high-strength, and earlier construction.

The low volume of coarse aggregates come at the expenditure of improved volume of cement powder, most important to high temperature production problems and higher expenses in

addition to the improved total shrinkage. To concentrate on these issues, the cement powder in SCC is moderately replaced with supplementary cementitious materials. Typically; these admixtures contain Fly Ash (FA), and Ground Granulated Blast-furnace Slag (GGBS).

SELF COMPACTING CONCRETE

Self-compacting concrete is a form of concrete that is capable of flowing in to the congested interior of form work passing through the reinforcement and filling it in a natural manner, consolidating under the action of its own weight without segregation and bleeding. It is made from almost the same ingredients as that of the conventionally vibrated concrete except that the relative proportions of these ingredients are to be carefully selected to impart self-compacting property to fresh concrete.

2 MATERIALS USED AND METHODOLOGY

2.1 cement

A cement is a binder, a substance used in construction that sets, hardens and adheres to other materials, binding them together. Cement is seldom used solely, but is used to bind sand and gravel (aggregate) together. Cement is used with fine aggregate to produce mortar for masonry, or with sand and gravel aggregates to produce concrete.Cement is the most usually used cementing ingredient in present day concrete comprises phase that consist of compounds of calcium silicon, aluminum, iron and oxygen. In this project we hired Commercially available 53grade ordinary Portland cement manufactured by Ultra Tech Cement with Specific Gravity of 3.2 and Fineness Modulus of 225m^2/kg used in all concrete mixes.

2.2 Aggregates

'Aggregate' is a term for any particulate material. It includes gravel, crushed stone, sand, slag, and recycled concrete and Geosynthetics aggregates. Aggregate may be natural, manufactured or recycled. Aggregates make up some 60 - 80% of the concrete mix. They provide compressive strength and bulk to concrete. Aggregates in any particular mix of concrete are selected for their durability, strength, workability and ability to receive finishes.

Depending upon the size the aggregates are classified into two types 1) Coarse Aggregate 2) Fine Aggregate

- Coarse aggregates are particulates that are greater than 4.75mm. The usual vary used is between 9.5mm and 37.5mm in diameter.
- Fine aggregates are usually sand or crushed stone that are less than 9.55mm in diameter

Coarse Aggregate Aggregates are primarily present, inert granular materials like sand, gravel, or crushed stone. But, technology is broadening to include the make use of recycled materials and man-made products. In this investigation used 12mm size aggregates are used.

Fig : 1 Coarse Aggregate

The particle fineness than 150um sieve are considered as fines. To achieve a balance between deformability or fluidity and stability, the total content of fineness has to be high, usually about 520 to 560kg/m3 According to IS 383:1970 the fine aggregate is being classify in to four similar zones that is zone-I, zone-II, zone-III, and zone-IV. In this investigation Zone-IV fine mixture as utilized in Self Compact Concrete

Fig : 2 Fine Aggregate

2.3 Fly Ash

Fly ash is classified into two types

1) Class F
2) Class C

Class F : It is normally low in lime, more often than not under 15%, and contains a greater combination of silica, alumina and iron (greater than 70%) than Class C fly ash.

Class C: Class C fly ash usually come from coals which may manufacture an ash with higher lime content generally more than 15% often as high as 30%. Fly ash conforming to the requirements of IS 3812 manufacturing from Rayalaseema Thermal Power Project (RTPP) in dharmal village near to Proddtur Kadapa district. The specific gravity of ash is two.2 and specific surface area of fly ash 280m2/kg was used as supplementary cementitious material in concrete mixtures.

Fig : 3 Cement and Flyash

Table 1: Chemical Compostion (%) of Fly ash

Compound	Content %Wt.
Sio_2	58
Al_2O_3	22.5
Fe_2O_3	5.75
TiO_2	5.6
Cao	2.12
MgO	1.6
SO_3	1.77
Na_2O	0.89
LOI	6.02

2.4 Ground Granulated Blast Furnace Slag (GGBS)

Ground Granulated Blast furnace slag(GGBS) could be a byproduct of Iron trade and that is obtained from throughout the manufacture of iron. The molten slag is a secondary product of sintering of the raw materials and this is quenched under high pressure of water jets, which results as granulates. The GGBS is obtained when the granulated slag is ground to a very fine powder with a specific surface area of 400-600m2/kg .The chemical composition of a slag vary significantly depends on the composition of the raw materials in the iron production process. Silicate and aluminates impurity from the ore and coke be mutually in the blast furnace with a flux which lowers the viscosity of the slag. In the case of iron manufacture the flux consists chiefly of a combination of rock and forsterite or at intervals some cases dolomite. In the blast furnace the slag float on top of top of the iron and is decant for separation. Slow cool of slag melts results in an uncreative crystalline material consisting of an collection of Ca-Al-Mg silicates. Towards get a good slag reactivity or hydraulicity, the slag liquefy desires to be rapidly cooled or quench below 800 °C in order to avoid the crystallization of merwinite and melilite. To cool and part the slag a granulation process can be applied in which molten slag is subjected to jet stream of water or air under pressure. Alternatively, in the pelletization process the liquid slag is partly cooled with water and consequently projected into the air by a rotate drum. In order to obtain a appropriate reactivity, the obtained fragments are ground to reach the same fineness as Portland cement.

Fig : 4 Ground Granulated Blast Furnace Slag

Table 2: Chemical Composition (%) of GGBS

Compound	Content %wt.
Cao	36.5
SiO_2	38.1
Al_2O_3	12.4
MgO	10.9
K_2O	0.6

2.5 Super Plasticizer Admixture

For self-compacting concrete, the best Super plasticizer is an admixture based in Polycarboxilates, do not guide by the brand of the admixtures because each producer have the personal name, The composition must be based in ethers of Polycarboxilates, the last generation of chemical superplastizicer admixtures. Materials which impart very high workability with a large reduce in water content for a specified workability. Super plasticizer is also called as High range water reducing admixture (HRWA) based on polycarboxylate ethers are typically used to plasticize the mix. Due to very low water-cement ratio, SCC is very susceptible to moisture fluctuations in the manufacturing process; therefore, stabilizers such at the same time as polysaccharides are added

The new invention of this type of admixtures is represented by polycarboxylate ether-based super plasticizers. With a moderately low dosage (0.15–0.3% by cement weight) they allow a water decrease up to 40%, due to their chemical structure which enables good particle dispersion. In this investigation I have used the super plasticizer as `SP430 manufactured by FOSROC Company.

Fig : 5 super plasticizer

2.6 Methodology:

The Methods Used In This Project Are As Follows:

Tests on materials

Table 3 : Tests Results Of Cement

Sl.No	Tests On Cement	Result	Requirement As Per Is 4031
1	Normal consistency	32%	Not to exceed 35%
2	Initial setting time	35min	>30 min's
3	Final setting time	500min	<600min's
4	Soundness test	2mm	Not exceed 10
5	Specific gravity	3.1	
6	Fineness modulus	2%	

Table 4 : Tests Results Of Fine Aggregates

Sl.No	Tests On FA	Result	Requirement As Per IS 2386
1	Fineness Modulus	2.32	2.3-2.7
2	Specific gravity	2.63	2.2-2.6
3	Water absorption	1%	<3%

Table 5 : Tests Results Of Coarse Aggregates

Sl.no	Tests On CA	Result	Requirement as per IS 2386
1	Fineness Modulus	4.32	3.4-6.0
2	Specific gravity	2.7	2.4-2.9
3	Water absorption	0.3	<0.6

Specific gravity of fly ash=2.25

Specific gravity of GGBS=2.9

2.7 mix proportions

The concrete mix design of M30 grade concrete by using European guide lines with water binder of 0.36 ratio.

Table 6 : Mix Proportion ID's

Mix Proprtion	mix Id
NORMAL CONCRETE,	A1
10% FLY ASH AND 0% GGBS	A2
10% FLY ASH AND 5% GGBS	A3
10% FLY ASH AND 10% GGBS	A4
10% FLY ASH AND 15% GGBS	A5

Mix proportion:

The following key proportions for the mixes listed below:

1. Air content (by volume)

2. Coarse aggregate content (by volume)
3. Paste content (by volume)
4. Binder (cementitious) content (by weight)
5. Replacement of mineral admixture by percentage weight of binder.
6. Water/ binder ratio (by weight)
7. Volume of fine aggregate/ volume of mortar
8. SP dosage by percentage cementitious (binder) weight

Table : 7 Proportions Of Ingredients

Mix Id	water/ binder ratio	cement kg/m^3	fly ash kg/m^3	ggbs kg/m^3	fine aggrgate kg/m^3	coarse aggregate kg/m^3	water kg/m^3
A1	0.36	452.3	0	0	850.8	771.84	191.88
A2	0.36	400	45.23	0	850.8	771.84	191.88
A3	0.36	384.46	45.23	22.615	850.8	771.84	191.88
A4	0.36	361.84	45.23	45.23	850.8	771.84	191.88
A5	0.36	339.23	45.23	67.84	850.8	771.84	191.88

- RCPT (RAPID CHLORIDE PERMEABILITY TEST)

Table : 8 Compression Test Result @Normal Curing

Mix Designation	Compressive strength N/mm^2
	28 days
A1	43.35
A2	33.79
A3	34.9
A4	31.03
A5	29.29

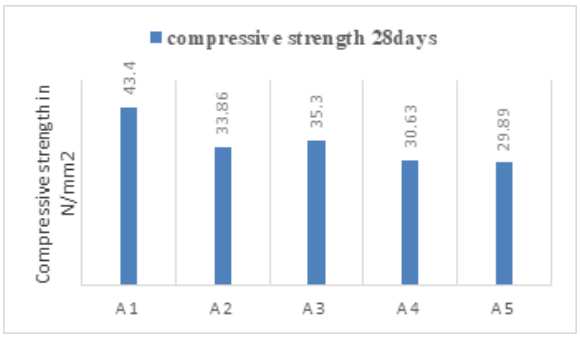


Fig 6: Compressive Strength test results (normal curing)

Table : 9 Fresh Properties Of Self Compacting Concrete

mix id	slumpflow value(mm)	L-box value	V-Funnel value
a2	670	0.89	9
a3	650	0.82	10
a4	630	0.81	13
a5	625	0.78	8

Table : 10 Compression Test Result @ Acid Attack

MixDesignation	Compressive strength N/mm^2	
	60 days	90 days
A1	32.89	41.06
A2	32.96	27.9
A3	36.5	40.52
A4	41.9	47.8
A5	31.98	31.2

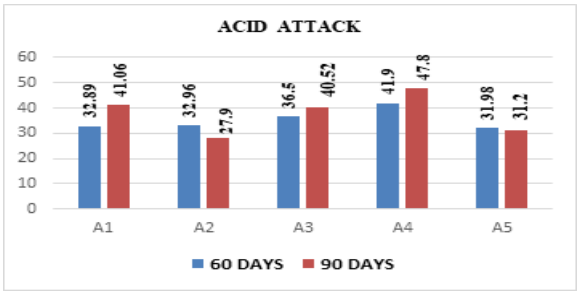


Fig : 7 Compressive Strength test results (Acid Attack)

2.8 EXPERIMENTAL INVESTIGATION

Concrete cubes of sizes 150 mm × 150 mm × 150 mm were tested for crushing strength. Compressive strength depends on loads of factor such as w/c ratio,

These cubes are tested by compression testing machine after 7 days, 14 days or 28 days curing

The following tests are conducted for the calculation of compressive strength.

- ACID RESISTANCE TEST
- SULPHATE ATTACK TEST
- ALKALINITY TEST

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As we observed the compressive test at age 60 days and 90 days strength of SCC at acid attackfor (30 days normal curing + 30 days acid curing), (30 days normal curing + 60 days acid curing) i.e. Total 60 &90 daysas 10% FA & 0% GGBS, from the graph we can clearly make a forward step towards the increase in compressive strength when the replacement of 10% flyash and 10% GGBS is done at acid curing in 60 days compared to all the remaining mixes.

Table : 11 Compression Test Result @ Sulphate Attack

Mix Designation	Compressive Strength N/Mm^2	
	60 Days	90 Days
A1	37.64	36.53
A2	39.06	38.4
A3	31.46	41.2
A4	44.03	41.66
A5	33.50	31.05

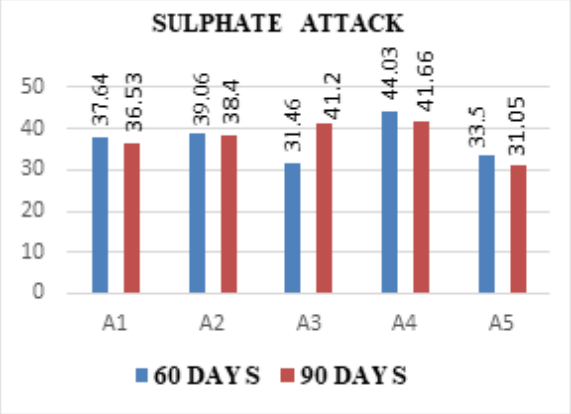

Fig : 8 Compressive Strength test results (Sulphate attack)

As we observed the compressive test at the age of 60 &90 days strength SCC at acid attackfor (30 days normal curing + 30 days sulphate curing), (30 days normal curing + 60 days sulphate curing) i.e. from fig: 6.3 we can notice in the sulphate attack the compressive strength the cube with 0% to 15% increase in fly ash and GGBS, increment was done in 10% Fly ash and 10% GGBS

Table : 12 Compression Test Result @ Alkalinity Test

Mix Designation	Compressive Strength N/Mm^2	
	60 Days	90 Days
A1	37.93	41.53
A2	42.6	45.96
A3	29.23	33.26
A4	38.06	39.83
A5	28.42	29.82

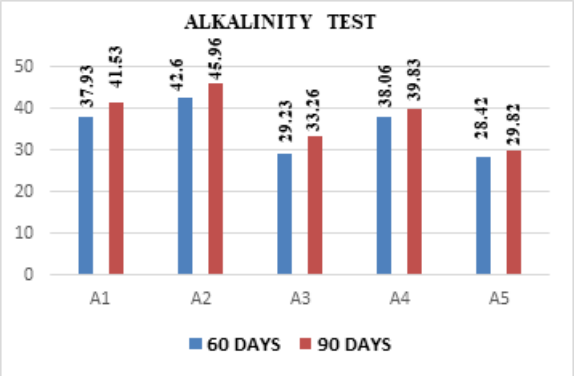

Fig : 9 Compressive Strength test results (Alkalinity Test)

The inference from the graph is the compressive strength at 60 & 90 days strength in SCC at alkalinity for (30 days normal curing + 30 days chemical curing), (30 days normal curing + 60 days chemical curing) i.e. Total 60 & 90 daysfrom the graph we can notice in that with the alkalinity attack the compressive strength the cube with 10% Fly ash to 0% GGBS increase initially and decrement of strength taken place.

Table : 13 Rcpt Values @28 Days & 60 Days

MIX PROPORTIONS	CHARGE PASSED (COULOMBS)	
	28DAYS	60 DAYS
A1	1652.5	1284.3
A2	1435.4	1056.24
`A3	1173.6	949.55
A4	1058.7	739.79
A5	1175.6	989.3

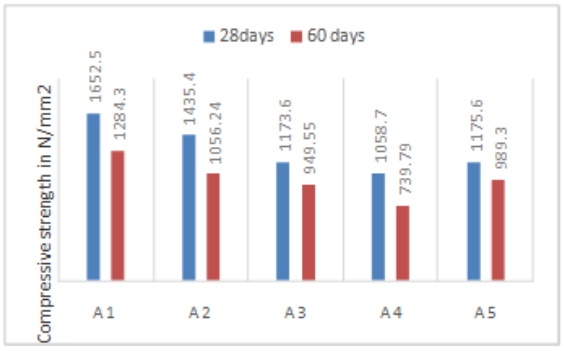

Fig : 10 RCPT Test Results

From the graph we can prove that, the chloride permeability is more in case of Normal concrete then it is decreased while adding GGBS 5%, 10% to the concrete for 60 days of curing. The chloride permeability of concrete with 10%FLY ASH + 10% GGBS is less while compared with the all proportions for 90 days.

2.9 conclusion

Based on the investigation conducted for the durability study on behavior of self-compacting concrete the results obtained are:

- By making the replacement of cement with GGBS increases consistency.
- With the use of super plasticizer, it possible to get a mix with low water to cement ratio to get the desired strength.
- According to our study, addition of FA to the concrete, can improve the fresh concrete properties.
- SCC mix which incorporates GGBS requires high dosage of super plasticizer to produce acceptable workability.
- The results shown that the use of FA and GGBS in concrete offsets the effect of GGBS has increasing the dosage of admixture in concrete to achieve fresh concrete properties.
- From this project we can conclude that the mix proportion 10% fly ash & 10% GGBS withstands all the strengths and we got optimum results for the above mix.
- Replacing cement with FA reduces the strength of SCC mix when compared with GGBS and Normal SCC mix
- The combined replacement of FA and GGBS cement shows increases in strength by increase in percentage replacement.
- SCC mix which incorporates of powder material comprising of 80% ordinary Portland cement, 10% Fly ash and 10% GGBS gives optimum values.

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