EFFECT OF FLY ASH AND GROUND GRANULATED BLAST FURNACE SLAG ON SELF COMPACTING CONCRETE

Nethikunta Ramesh[1], Mr. Srinivas Rao[2] and Dr. B. Sharath Chandra[3]

[1]*PG Scholar*

[2]*Assiatant Professor*

[3] *Assiatant Professor,Head Of the Department, Ellenki College of Engineering and Technology, Patelguda, Patancheruvu, Sangareddy.*

ABSTRACT

Due to its enhanced production techniques, self-compacting concrete is being used in more concrete production every day. One kind of concrete that is thought to be cohesive enough to be handled without bleeding or segregation is SCC, which may be placed and compacted with little to no vibration effort. It is used to facilitate and ensure proper filing of constrained areas, substantially reinforced structural components, and optimum structural performance. In this study, self-compacting concrete (SCC) mixes are made by combining fly ash and ground granulated blast-furnace slag, two supplementary cementitious materials (SCMs). SCMs were added to the mixtures in varied quantities to replace the cement.

1. INTRODUCTION

1.0. GENERAL

It is not required to emphasize the versatility and applications of concrete in the construction industry. Normal and high strength concrete research has been a top emphasis for more than 20 years. Ordinary concrete is defined as having an MPa value between 25 and 55 by IS: 456-2000 [Code of Practice for Plain and Reinforced Concrete], while high strength concrete is defined as having an MPa value more than 55. The MPa value of ultra-high strength concrete must be more than 120/150. High strength concrete is utilized in a wide variety of buildings all over the world, including tall skyscrapers, long-span bridges, and structures in dangerous environments. Building components made of high strength concrete are often significantly reinforced. Congestion brought on by the reinforcement presents serious challenges while laying concrete. To get around problems with densely reinforced concrete, utilize concrete that is easily diffused between the packed reinforced concrete parts. Such a concrete might provide a highly thick, uniformly distributed, and homogeneous concrete.

1.1 Self-Compacting Concrete

Self-Compacting Concrete (SCC) is a sort of concrete that is cohesive enough to be handled without segregation or bleeding while simultaneously being able to be placed and compacted by its own weight with little to no manual effort. It is utilized to assist and assure effective filling of confined regions and extensively reinforced structural components, as well as optimum structural performance. Self-Consolidating Concrete lessens the heavy manpower need for vibration of very packed portions. There is also no risk of material component separation since this concrete may spread easily without any mechanical consolidation. It is feasible to ensure the performance of such an SCC by carefully planning for low yield value and a moderate viscosity to maintain high deformability and filling capacity of the form work, with minimum segregation and flow blockage. More understanding of a good performance SCC is needed in order for such performance concrete to be more widely accepted for casting complicated and crowded structural parts, especially in seismic locations, with high reinforcing.

Fig.1: Self-Compacting Concrete

1.1.1 Characteristics of SCC:

Due to a manpower shortage, a need to stop concrete from vibrating, and a desire to reduce the number of construction-related problems, SCC was developed in Japan. SCC must meet strict requirements in terms of filling ability, passing ability, and segregation resistance in order to uniformly fill a mould. Even in the presence of substantial steel bar reinforcement, the concrete must fill a mould entirely without leaving any trapped air due to its own weight. Both in motion and at rest, the components must be evenly distributed. The features of SCC in the hardened stage are influenced by the clustering of the aggregates near the reinforcement (blocking) and the separation of paste or water. The key characteristics of SCC are listed below.

Filling Ability:

SCC must flow both horizontally and vertically without catching air at the surface or inside the concrete itself, and it must fill up any voids in the form work without disturbing the concrete. The process's driving forces are the weight of the concrete and the casting energy. To get an adequate flowing ability, SCC mixes must be noticeably more workable than traditional vibrated concrete. The primary factor affecting the mixture's workability is the quantity of water present. The more water to cement there is, within a certain range, the easier it will be to mix the concrete. However, when the water to cement ratio increases, the hardened strength of concrete will generally deteriorate. Two further significant factors that have a significant influence on how readily concrete may be worked are the aggregate's characteristics and the mix's aggregate to cement ratio. A high surface area to volume ratio of aggregate will increase the amount of water required for a certain workability of the concrete mix. Additionally, angular aggregates need more water for a given workability. The aggregate/cement ratio also affects the inter-particle friction between aggregate particles. A higher aggregate/cement ratio will result in more aggregate interlocking and a stronger inter-particle connection. friction, which leads to concrete that is difficult to handle. However, since the latter part of the 1960s, it has been possible to produce great workability concrete with relatively low water/cement ratios without adding extra water by including plasticizers or super plasticizer into the mixture. As a result, SCC employs cutting-edge super plasticizer technology to provide the mix a high level of workability, allowing it to flow into all spaces inside the form work without segregation. Slump flow and timings of the flow The methods used to measure filling capacity include T50 and T60, V-funnel, Orimet, U-Box, and L-Box.

2. LITERATURE REVIEW

Ozawa et al. (1989) studied how mineral admixtures affected the flowability and segregation resistance of self-compacting concrete. They observed that using fly ash and blast furnace slag to partially replace OPC considerably improved the concrete's ability to flow. He arrived to the conclusion that the ideal qualities for cement's ability to flow and strength were 10 to 25 percent fly ash and 25 to 45 percent slag by mass.

SCC mix was subjected to a slump flow test by **Nagataki and Fujiwara (1992)** to determine whether or not the concrete mix was workable. They also conducted a segregation test on the SCC mix using ingredients that were readily accessible in the area. A slump of 500 to 700 mm is thought to be necessary for concrete to self-compact.

A slump test was conducted for concrete with great workability by **Domone and His-Wen (1997).** The laboratory test produced a helpful link between the slump levels and flow. It demonstrated the slump flow's gratifying worth.

Naik and Singh (1997) carried out studies to determine the compressive strength of concretes containing 15% to 25% by mass of Class F and Class C fly ashes. We also considered how temperature and moisture impacted curing. The results of the investigation showed that Class C fly ash concretes wet cured at 73°F (23°C) produced early age compressive strengths larger than Class F fly ash concretes (1 to 14 days). The long-term (90 days and above) compressive strength of concretes containing fly ash was not significantly affected by the class of fly ash. Class C fly ash-containing air-cured concretes exhibited compressive strengths that were typically greater than those of Class F fly ash-containing air-cured concretes, but Class F fly ash-containing air-cured concretes did not obtain values equal to those of air-cured normal concretes. For concretes containing either kind of fly ash, the compressive strengths at 7 days rose with higher curing temperatures.

Bertil Persson (2001) investigated the mechanical properties of self-compacting concrete and the associated properties of normally compacting concrete, including strength, elastic modulus, creep, and shrinkage, by experimental and computational methods. The experiment comprised eight mix proportions of sealed or air-cured specimens with water binder ratios (w/b) ranging from 0.24 to 0.80. 50% of the mixes were made up of SCC, while the remaining 50% were made up of NCC. The age of the concretes during loading in the creep studies varied from 2 to 90 days. Strength and relative humidity were also found. The results showed that the elastic modulus, creep, and shrinkage of SCC were similar to those of equivalent NCC properties.

In 2002, Xie et al. developed the preparation process for high strength self-compacting concrete (SCC) using ultra pulverized fly ash (UPFA) and superplasticizer (SP). After selecting a number of concrete criteria, including as excellent workability, high mechanical qualities, and great durability, SCC was developed. There was some slump loss in the new SCC composition. The workability of high strength SCC containing UPFA and SP may be evaluated using the approach of combining slump flow and L-box test. There was a slump flow of 600–750 mm. The flow rate for the L-box test varied from 35 to 80 mm/sec.

Trials conducted to determine a rough mix proportioning for self-compacting concrete were detailed by Subramanian and Chattopadhyay (2002). Self-compatibility was attained when coarse aggregate and sand content were limited to 46% and 40% of the mortar volume, respectively, for water to powder ratios ranging from 0.9 to 1.1.

According to R.V. (2003), using fine fly ash to create self-compacting concrete increased its 28-day Compressive Strength Concrete by roughly 38%. Concrete that self-compacted was produced when the paste volume was between 0.43 and 0.45.

Lachemi and Hossain presented their 2004 inquiry on the suitability of four different types of Viscosity Modifying Agents (VMA) in the production of SCC. The features of both fresh and hardened SCC were studied by introducing different VMA into SCC. To evaluate the deformability through limited areas, apply the v-funnel test. In this experiment, concrete was allowed to flow out of the funnel because the bottom outlet was left open while the funnel was completely filled with concrete. The interval between the outlet opening and the flow seizure was observed. Low deformability may be related to flow time due to excessive paste viscosity, higher interparticle friction, or flow blockage. Concrete must flow for fewer than 6 seconds in order to be categorized as SCC. All of the mixtures were successful, and none notably segregated or clogged the aggregate.

Cengiz (2005) substituted fly-ash with SCC for standard Portland cement (NPC) in varying proportions of 0%, 50%, and 70%. He looked at the HVFA (high volume fly ash) self-compacted concrete's strength characteristics. Both wet and dry curing conditions were used to cure concrete mixes prepared with water cementitious material ratios ranging from 0.28 to 0.43. He looked into the mix's strength characteristics and established a link between compressive strength and flexural tensile strength. The research demonstrated that the application of an appropriate superplasticizer may transform RCC (zero slump) concrete into a workable concrete.

In 2005, Felekoglu et al. performed research on the effect of the w/c ratio on the initial and hardened features of SCC. The author claims that adjusting the w/c ratio and superplasticizer dosage is one of the most important aspects of proportioning SCC mixtures. In this research, fine mixes with varied w/c ratios and superplasticizer dosage combinations were the subject of the examination. According to the study's conclusions, the best w/c ratio for the manufacturing of SCC is between 0.84 and 1.07 by volume. The percentage above and below this range may cause the mixture to block or segregate.

Kumar (2006) described the SCC development's history and guiding concepts. In order to evaluate the segregation resistance of self-compacting concrete built with fly ash (FA), he also looked at its properties in 2008. He used a range of testing methodologies. FA was used in place of Portland Cement (PC). PC was replaced to a maximum of 80% by fly ash. For all of the combinations, the water binder ratio was held constant at 0.36. This research examined workability, shrinkage, absorption, and ultrasonic pulse velocity in addition to strength properties. According to the findings, 40% replacement of FA produced strength more than 65 N/mm2 after 56 days. The high absorption values and less than 2% absorption were seen when the quantity of fly ash was increased.

Ferrara et al. (2006) assessed the HLSCC for all the fundamental qualities, including flowability, segregation resistance, and new concrete filling capacity. The slump flow tests (to measure flowability) and the amount of time needed to achieve 500 mm of slump flow

All mixes met the expected capacity level for the HLSCC's (S) (for measurement of segregation resistance ability), but only the bulk of the LC mixed concrete (mix nos. 2-4) and one of the mixed concretes (mix nos. 6). It is observed how long it takes for the water to fully flow through the V-funnel.

In 2007, Sahmaran et al. released a paper on the analysis of the mechanical and fresh properties of a fiber-reinforced self-compacting concrete incorporating high-volume fly ash in mixes containing fly ash. For 50% of the weight of the cement, fly ash was utilized in stead. All mixes' slump flow widths were found to be between 56 and 700 mm, which is the permissible range, and the average slump flow time was less than 2.9 seconds.

Khatib (2008) looked at the properties of fly ash-containing self-compacting concrete (FA). FA was used in place of Portland Cement (PC). PC was replaced to a maximum of 80% by fly ash.

For all of the combinations, the water binder ratio was held constant at 0.36. This research examined workability, shrinkage, absorption, and ultrasonic pulse velocity in addition to strength properties. The results showed that after 56 days, 40% replacement of FA provided strength more than 65 N/mm2. When the amount of fly ash was increased, the high absorption values and less than 2% absorption were observed.

N. Both Bouzouba and M. Lachemi conducted an experimental investigation on creating and assessing SCC created with significant amounts of fly ash. Except for one, the high-volume fly ash self-compacting concretes had slump flows between 500 and 700 mm, flow times between 3 and 7 seconds, segregation indices between 1.9 and 14%, and bleed water ranges between 0.025 and 0.129 mL/cm2. At 7 and 28 days, the self-compacting concrete exhibited compressive strengths ranging from 15 to 31 MPa and from 26 to 48 MPa.

3. Materials & Methodology

1. Cement
2. Coarse Aggregate
3. Fine Aggregate
4. Fly Ash
5. Super plasticizer
6. Viscosity Modifying Agent
7. Water

3.1.1 Cement:

Ordinary Portland cement of grade 53 was used in the study (IS: 12269-1987, Specifications for 53 Grade Ordinary Portland cement). It was preserved in compliance with IS: 4032 - 1977 and received from a single source. Care has been taken to only use cement from the same company and grade throughout the investigation. The physical properties of the cement that was so produced were evaluated in accordance with IS: 12269 - 1987. Table 4.2.1 displays the physical characteristics of the hydraulic cement that was evaluated in accordance with IS: 4031-1988 [Methods of physical testing for hydraulic cement].

Table: 1 Physical properties of Ordinary Portland Cement

S.No	Property	Test method	Test results	IS standards
1.	Normal consistency	Vicat apparatus (IS:4031 part-4)	30%	
2.	Specific gravity	Sp.Gr.bottle(IS:4031 Part-4)	3.09	
3.	Initial setting time Final setting time	Vicat apparatusIS: 4031 part-4	96 minutes 207 minutes	Not less than 30 minutes Not less than 10 hours
4.	Fineness	Sieve test on sieve	1.3%	10%

3.1.2. Fine Aggregates

Locally available river sand that conformed with IS: 383 - 1970 [Methods of physical testing for hydraulic cement] and was free of any organic pollutants was used as the fine aggregate. The fine aggregate was tested for its physical characteristics, including gradation, fineness modulus, specific gravity, and bulk density, in accordance with IS: 2386 - 1963 [Methods of test for aggregate for concrete.

3.1.3. Coarse Aggregate

Compared to the coarse aggregate used in conventional concrete, the coarse aggregate used in SCC was often rounded, well-graded, and had a smaller maximum size. The size of the coarse particles used in self-compacting concrete ranged from 10 to 16 mm. Concrete flows and deforms more freely with the aid of rounded and smaller aggregate particles, which also lessen segregation. For concrete casting, graded aggregate is essential, particularly if there is little formwork or reinforcement. Crushed granite metal with diameters ranging from 16 mm to 10 mm was obtained from neighboring quarries and used in the present experiment. They were examined in accordance with IS 383-1970 [Methods of physical testing for hydraulic cement]. Examples of physical properties include specific gravity, bulk density, flakiness index, elongation index, and fineness modulus.

3.1.4 Water

Used for mixing and curing was potable water that conformed with IS: 3025 - 1964 part22, part23, and IS: 456 2000 [Code of Practice for Plain and Reinforced Concrete]. There were no traces of salts, sugar, oils, acids, or other organic substances that may damage steel or concrete in this water. The pH level should not be less than 6. The solids were within the permitted limits of IS: 456 - 2000 article 5.4.

3.1.5 Fly Ash

One of the most often used supplementary cementitious materials in the construction industry is fly ash, which mimics Portland cement. It is an inorganic residue that is finely divided and recovered or precipitated from any industrial furnace's exhaust gases. It is inorganic and noncombustible. Most fly ash particles are solid spheres, but some of them, called cenospheres, are hollow spheres and others, called plerospheres, are spheres with smaller spheres within. With an average particle size of twenty micrometers or less, fly ash may include particles as tiny as one micrometer and as big as one hundred micrometers. Although certain fly ashes may have surface sizes between 200 and 700 m2/kg, they typically have a surface area between 300 and 500 m2/kg. The bulk of fly ash is composed of silicate glass, which includes calcium, alumina, iron, and silica. Fly ash usually has a grey color and a relative density, or specific gravity, between 1.9 and 2.8.

In this experiment, fly ash from the Kakatiya Thermal Power Project in Andhra Pradesh, India, was used. This is confirmed by IS: 3812 - 1981 grade I, "Specifications for Fly Ash for Use as Pozzolana and Admixture." It underwent testing in accordance with IS: 1727 -1967 [Methods of test for pozzolana materials]. The typical oxide concentration of Indian fly ash is shown in Table 4.3. Tables 4.3.1 list the chemical composition and physical characteristics of the fly ash used in the present experiment.

Table: 2 Typical chemical Composition of Indian fly ash

S No	Characteristics	Percentage
1.	Silica, SiO2	49-67
2.	Aluminia, Al2O3	16-28
3.	Iron oxide Fe2O3	4-10
4.	Lime Ca O	0.7-3.6
5.	Magnesia Mgo	0.3-2.6
6.	Sulphur trioxide SO3	0.1-2.1
7.	Loss on ignition	0.4-1.9
8.	Surface area m^2/kg	230-600

Table :3 Chemical Requirements of Fly ash

S No	Characteristics	Requirements (% By weight)	Fly ash used(% By weight)
1.	Silicon dioxide(sio2) plus Aluminium oxide.plus(Al2O3)plus,iron oxide(Fe2O3)	70(minimum)	94.46
2.	Silicon dioxide (SiO2)	35(minimum)	62.94
3.	Magnesium oxide (MgO)	5 (max)	0.60
4.	Total sulphur as sulphur trioxide(SO3)	2.75 (max)	0.23
5.	Available alkalies as sodium oxide(Na2O)	1.5 (max)	0.005
6.	Loss on ignition	12 (max)	0.30
7.	Chlorides		0.009

3.1.6 GROUND GRANULATED BLAST FURNACE SLAG.

JP Cements in Bellary, Vijayawada, India provided the GGBS. It has a 2.72 specific gravity. The GGBS's chemical make-up is shown in Table 4.3. The main components that promote pozzolanic reaction in a cement-based material are SiO2, Al2O3, and CaO, which are the dominating oxides in the GGBS (Awoyera et al., 2017). According to IS: 1727 -1967 [Methods of test for pozzolana materials], it was put through testing.

Table :4 Chemical requirements of GGBS

Oxide	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO
Concentration (%)	35.47	19.36	0.8	33.25	8.69

3.1.7 Superplasticizer

In order to boost flow or workability for lower water-cement ratios without reducing compressive strength, super plasticizers, a high range water lowering addition, are used. These admixtures significantly lower the viscosity of the paste when they disperse in cement agglomerates by forming a thin film around the cement particles. The British Standards Institution's (BSI) 5075 part.3 (British Standards Institution), ASTM C - 494 (Standard Specification for Chemical Admixtures for Concrete), and IS 9103: 1999 (Specification for Admixtures for Concrete) requirements were all met by the water-reducing admixture Glenium used in the current study. Information on the super plasticizer used is provided in Table 4.4.1.

Table: 5 Details of Super Plasticizer

S No	Property	Result
1.	form or state	liquid (sulphonated naphthalene based formaldehyde)
2.	Colour	Brown
3.	Specific gravity	1.220 to 1.225 at 30°C
4.	Chloride content	Nil to IS : 456
5.	Air entrainment	Approx.1% additional air is entrained
6.	Compatibility	Can be used with all types of cements except high alumina cement . conplast SP430 is compatible with other types of fosroc admixtures when added separately to the mix.
7.	Workability	Can be used to produce flowing concrete that requires no compaction
8.	Cohesion	Cohesion is improved due to dispersion of cement particles thus minimising segregation andimproving surface finish
9.	Compressive strength	Early strength is increased upto 20%. Generally,there is improvement in strength upto 20% depending upon W/C ratio and other mix parameters.
10.	Durability	Reduction in w/c ratio enables increase in density and impermeability thus enhancing durability of concrete
11.	Dosage	The rate of addition is generally in the range of 0.5 - 2.0 litres /100 kg cement

3.2 BATCHING AND MIXING OF SCC

Amounts of cement and other cementitious materials like GGBS are proportioned. According to the Nan-Su mix design, fly ash, fine aggregate, and coarse aggregate have all been measured by weight. Super plasticizer and water were volumetrically measured. All measurement instruments are kept in pristine working order, and their accuracy is routinely tested. A concrete mixer that runs on electricity does the mixing. The components are placed down in regular layers, one on top of the other and in the following order: cementitious material, fine aggregate, and coarse aggregate. In order to get a consistent color, dry mixing is used. Prior to mixing, the fly ash and GGBS are well combined with cement. Testing for the self-compacting properties of freshly mixed concrete is done according to EFNARC requirements [2005]. The workability characteristics of Normal Concrete (NC) included a 0.9 compaction factor and a slump that was maintained in the 75 to 100 mm range. By modifying the mineral and chemical admixtures, greater strength concretes are kept at that level.

3.2.1 Mix Proportion

Table 6: Mix Proportions of Cement Concrete

CEMENT	FLY ASH	COARSE AGGREGATE	FINE AGGREGATE	WATER
345 Kg/m3	245 Kg/m3	750Kg/m3	886 Kg/m3	190 Kg/m3
345/345=1	0.71	2.57	0.55	0.55(W/C), 0.32(W/P)

4. EXPERIMENTAL RESULTS

4.1 Mix design based on Exact Nan SU Method with Fly ash

4.1.1 Mix trial 1:

Table:7 Mix Proportion of SCC with fly ash

		Mix Proportions in Kg/m^3					
	PF	CA	FA	Cement	Fly ash	SP	Water
M 40	1.12	750	886	345	216	0.050	190

Table 8: Properties of Coarse aggregate and Fine aggregate

Properties	Coarse Aggregate	Fine aggregate
Bulk Density	1.45	1.43
Specific Gravity	2.81	2.62
Fineness Modulus	7.3	2.54

Table.9: Fresh properties of Self Compacting Concrete (M40 Grade) Fly ash

S.No	Method	Unit	Fresh Properties	EFNARC Specifications
			flash	Min – Max Values
1.	Slump flow by Abrams cone	Mm	550	650 - 800
2.	T50 cm	Sec	3.47	2 – 5
3.	V-funnel (Time for complete discharge)	Sec	6.37	0 – 10
4.	V-funnel at T5 Minutes	Sec	18	6 – 12
5.	J-ring	Mm	-	0 – 10
6	L-box(h2/h1)		-	0.8 – 1.0

Table 10: Compressive strength of Self Compacting Concrete with fly ash

Grade of Concrete(M40)	Compressive strength in N/mm^2			Average (N/mm^2)
Fly Ash based Scc	52.8	51.2	51.9	51.9

4.1.2 Mix trial 2:

Table.11 Mix Proportion of Scc with Fly ash

		Mix Proportions in Kg/m^3					
	PF	CA	FA	Cement	Fly ash	SP	Water
M 40	1.12	785	936	345	160	0.050	190

Table.12 Fresh properties of Self Compacting Concrete (M40 Grade) with fly ash

S.No	Method	Unit	Fresh Properties fly ash	EFNARC Specifications Min – Max Values
1.	slump flow by Abrams cone	mm	530	650 - 800
2.	T50 cm	Sec	2.56	2 - 5
3.	V-funnel (Time for complete discharge)	Sec	4.68	0 - 10
4.	V-funnel at T5 Minutes	Sec	4.94	6 - 12
5.	J-ring	Mm	-	0 - 10
6	L-box(h2/h1)		-	0.8 – 1.0

Table.13 Compressive strength of Self Compacting Concrete

Grade of Concrete(M40)	Compressive strength in N/mm^2			Average (N/mm^2)
Fly Ash based Scc	51.8	50.2	50.9	51

4.2 Mix design based on Exact Nan SU Method with GGBS

4.2.1 Mix trial 1:

Table 14 .Mix Proportion of SCC with GGBS

		Mix Proportions in kg/m^3					
	PF	CA	FA	Cement	GGBS	SP	Water
M 40	1.12	785	936	345	216	0.050	190

Table 15. Fresh properties of Self Compacting Concrete (M40 Grade)

S.No	Method	Unit	Fresh Properties	EFNARC Specifications
			GGBS based Scc	Min – Max Values
1.	Slump flow by Abramscone	mm	590	650 - 800
2.	T50 cm	Sec	2.37	2 - 5
3.	V-funnel (Time for complete discharge)	Sec	6.37	0 - 10
4.	V-funnel at T5 Minutes	Sec	14.46	6 - 12
5.	J-ring	mm	-	0 - 10
6	L-box(h2/h1)		-	0.8 – 1.0

Table.16 Compressive strength of Self Compacting Concrete

Grade of Concrete(M40)	Compressive strength in N/mm^2			Average (N/mm^2)
GGBS based Scc	53.5	51.92	51.25	52.22

4.2.2 Mix trial 2:

Table 17 .Mix Proportion of scc with GGBS

		Mix Proportions in kg/m^3					
	PF	CA	FA	Cement	GGBS	SP	Water
M 40	1.12	785	936	345.	216	0.05	190

Table. 18. Fresh properties of Self Compacting Concrete (M40 Grade)

S.No	Method	Unit	Fresh Properties	EFNARC Specifications
			GGBS based Scc	Min – Max Values
1.	Slump flow by Abrams cone	mm	560	650 - 800
2.	T50 cm	Sec	2.15	2 - 5
3.	V-funnel (Time for complete discharge)	Sec	6.15	0 - 10
4.	V-funnel at T5 Minutes	Sec	6.59	6 - 12
5.	J-ring	mm	15	0 - 10
6	L-box(h2/h1)		1.8	0.8 – 1.0

Table 19. Compressive strength of Self Compacting Concrete

Grade of Concrete(M40)	Compressive strength in N/mm^2			Average (N/mm^2)
GGBS	52.31	53.64	55.64	53.86

4.3 Interpretation and Discussion of Test Results

The characteristics of the research include the impact of fly ash and GGBS, aggregate size (4.75, 10, 12, 5 mm), curing time (3, 7 and 28 days), concrete grade (M40), and concrete type (SCC).

4.3.1 Discussion of the mix ratios used for the SCC

As previously mentioned, the Nan Su technique of mix design [2001] was used to create the SCC mix for concrete of the M40 grade. As is clear, the foundation of the Nan Su technique is the filling of aggregate voids with paste binders to ensure that the resulting concrete has the required SCC qualities, including the ability to flow and self-compact. For concrete of the M40 grade, the packing factors anticipated on the basis of greater compactability and strength, from a number of experiments, are 1.12.

According to the Nan Su approach of mix design for SCC, the density, compactability, and strength are all determined by how effectively the aggregates are packed. As a consequence, the aggregate's size, shape, and texture affect the values of its fresh and hardened features.

The mix % of M40 grade Self Compacting Concrete was developed using the Nan Su approach of mix design with fly ash and GGBS in accordance with the specifications of EFNARC from table 6.3.1.

4.3.2 Comparison Of Results:

Mix proportion(M40)

Table 20: Mix proportions for M40

Mix proportions	Fly ash based Scc Kg/m^3		GGBS based Scc kg/m^3	
	Mix 1	Mix 2	Mix 1	Mix 2
Packing Factor	1.12	1.12	1.12	1.12
Cement	345	345	345	345
Coarse aggregate	750	785	785	785
Fine aggregate	886	936	936	936
Fly ash	216	160	216	160
SP	0.050	0.050	0.050	0.050
Water	190	190	190	190

Fresh Properties:

Table 21: Workability of Concrete Results

S.No	Method	Unit	Fly ash based Scc		GGBS based Scc	
			Mix 1	Mix 2	Mix 1	Mix 2
1.	Slump flow byAbrams cone	mm	550	530	590	560
2.	T50 cm	Sec	3.47	2.56	2.37	2.15
3.	V-funnel (Timefor complete discharge)	Sec	6.37	4.68	6.37	6.15
4.	V-funnel at T5Minutes	Sec	18	4.94	14.46	6.59
5.	J-ring	mm	-	-	-	15
6	L-box(h2/h1)		-	-	-	1.8

Hardened Properties:

Table 22: Compressive Strength Results

Grade of Concrete(M40)		Compressive strength in N/mm^2			Average (N/mm^2)
Fly ash	Mix 1	52.8	51.2	51.9	51.9
	Mix 2	51.8	50.2	50.9	51
GGBS	Mix 1	53.5	51.95	51.25	52.22
	Mix 2	52.31	53.64	55.64	53.86

4.4 BEHAVIOUR OF FLY ASH AND GGBS ON FRESH PROPERTIES

Fly ash's impact on SCC's fresh characteristics

To investigate the impact on the filing ability of SCC, fly ash substituting regular Portland cement of grade 53 by mass percentage and dosages of superplasticizer (1%) have been utilized. For all trail combinations, the water to cement ratio of 0.42 was maintained. The Efnarc specifications have met the slump test, v-funnel test, and J-ring test for the fresh qualities of scc with fly ash from mix trials 1 and 2.As a result, we may utilize Fly ash in lieu of Opc in SCC, as shown in table 6.3.2.

The impact of GGBS on the SCC's fresh characteristics

To investigate the impact on the filing ability of SCC, GGBS has been utilized to replace by mass proportion ordinary Portland cement of 53 grade and dosages of superplasticizer (1%). For all trail combinations, the water to cement ratio of 0.42 was maintained. The slump, v-funnel, and J-ring tests for the fresh qualities of scc with GGBS from mix trials 1 and 2 also met the Efnarc requirements. Therefore, we may utilize GGBS in lieu of the OpC in SCC. Figure 6.3.2

4.5 BEHAVIOUR OF FLY ASH AND GGBS ON MECHANICAL PROPERTIES

In 7.4.1, the effect of fly ash on the mechanical properties of SCC is covered.

To determine the range of permitted strengths for self-compacting concretes, compression testing was performed on 150mm cube specimens for all combinations. A summary of the compressive strength test results for all self-compacted concrete mixes tested up to a 28-day age is given in Section 5.3.3. It was shown that the compressive strength for SCC samples reduced symmetrically as the fly ash [FA] content rose. When the fly ash content of the SCC samples was 28 days old, the compressive strengths of the first [M40] and second [M40] trail mixture groups were 51.9 and 51 MPa, respectively. This shows that the compressive strengths of the SCC samples for all 28 days decreased when the fly ash content rose from 6.3.3 to 51 MPa.

Effect of GGBS on the mechanical characteristics of SCC

When GGBS is utilized as a cement alternative, consistency is improved. The allowable strength range of the self-compacting concretes was determined by a compression test on 150mm cube specimens for each trail combination. The results of the compressive strength tests for all self-compacted concrete mixes tested up to a 28-day age are summarized in Section 6.3.3. The quantity of fly ash (FA) found in the SCC samples was shown to produce a symmetric drop in compressive strength. In accordance with the compressive strengths of the first [M40] and second [M40] trail mixture groups, the fly ash content of scc at 28 days was 52.2 MPa and 53.86 MPa, respectively. This shows that the compressive strengths of SCC samples for all 28 samples decrease from 6.3.3 as fly ash concentrations increase. When compared to fly ash, scc that contains ggbs has a higher compressive strength.

5. CONCLUSION

The meticulous and exhaustive experimental research of SCC mixes that was conducted with the goal of developing performance mixes led to the following conclusions.

It was feasible to get the necessary slump flow diameter of 700 mm for all SCC mixes by adjusting the quantity of the super plasticizer used for the testing batches. To stay within the confines of the targeted slump flow diameter, the amount of HRWRA (High Range Water Reducers Admixture) was increased at the same rate as the level of fly ash concentration.

The slump flow, T50 time, V-funnel time, and L-box height ratio tests used to assess the fresh state characteristics for different mixes are in compliance with the EFNARC Guidelines, and better outcomes are obtained when fly ash concentration is raised.

Project's major contribution: The present experiment has unmistakably shown how the aggregate size impacts self-compacting concrete's compressive strength and other mechanical properties.

REFERENCES:

1. Bouzoubaa N, Lachemi M. “Self-compacting concrete incorporating high volumes of class F fly ash: Preliminary results”, Cement and Concrete Research, 2001, Vol. 31, No.3, pp 413-420.

2. EFNARC. “Specification and guidelines for self-compacting concrete”, European Federation of Producers and Applicators of Specialist Products for Structures, 2002.

3. EFNARC. “Specification and guidelines for self-compacting concrete”, European Federation of Producers and Applicators of Specialist Products for Structures.

4. Jaya Shankar R, Hemalatha T, Palanichamy.K and Santhakumar. S, “Influence of fly ash and VMA on properties of self-compacting concrete”, National Conference on Advances in materials and mechanics of concrete structures Department of Civil Engineering, IIT Madras, Chennai 12-13 August 2005, pp 25 – 32.

5. Nan Su, Kung-Chung Hsub and His-Wen Chai. “A simple mix design method for self- compacting concrete”. Cement and Concrete Research, 2001, Vol. 31, pp 1799 – 1807.

6. Okamura H, Ozawa K. “Mix design for self-compacting concrete”. Concrete Library of Japanese Society of Civil Engineers, 1995, Vol. 25, No. 6, pp 107-120.

7. Okamura Hajime and Ouchi Masahiro. “Self – Compacting Concrete”. Journal of advanced concrete technology, 2003, Vol.1, No.1, pp 5 – 15.

8. Ouchi M, “Current conditions of self-compacting concrete in Japan”. The 2nd International RILEM Symposium on Self-Compacting Concrete, 2001.Ozawa K, Ouchi M, editors, pp 63 68.

9. Subramanian, S. and Chattopadhyay D. “Experiments for mix proportioning of self- compacting.