A COMPARATIVE STUDY ON MECHANICAL PROPERTIES OF SCC BY PARTIAL REPLACEMENT OF CEMENT WITH FLY ASH & GGBS WITH THE USE OF GLASS FIBERS

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Abstract

Concrete is a versatile material that can be used for construction of all kinds or shapes of structural elements. Self Compacting Concrete (SCC) was developed by the Japan researchers in the year 1989. SCC is a special type of concrete that is competent or capable to flow and consolidate under its own weight without any segregation and bleeding between the reinforcing bars. SCC is one of the widely used types of concrete in the current world because it makes the work easier and it does not bleed at the joints of the moulds. In this work, an attempt has been made to prepare a high strength SCC of grade M60 by partially replacing the cement content with the untreated industrial byproducts like fly ash & ground granulated blast furnace slag (GGBS) and also by replacing 100% of natural sand with manufactured sand (M.Sand). With the use of these industrial byproducts, it results in an eco-friendly environment and also solves the problem of its disposal. The present work deals with the comparative study on mechanical properties like compressive strength, split tensile strength and flexural strength of SCC for various percentages of powder contents with the use of glass fibers at 0%, 0.1% & 0.2% to the total volume of the concrete mix. In this study two types SCC mixes were prepared namely, Conventional SCC in which cement content was replaced by 30% with fly ash and Triple blended SCC in which cement content was reduced to 50% & the rest of the cement content was replaced with fly ash & GGBS by 25% each. The specimens are casted, cured & tested for the required number of days.

Keywords: *SCC, Fly Ash, GGBS, Glass Fiber & Mix Design.*

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1. INTRODUCTION

The adaptability as well as use of concrete in construction engineering not required to be explained. Many investigations on Normal & High Strength Concrete(HSC) are being carried out from past thirty years. According to IS456 – 2000 (Indian code for plain and RC structures), the strength of concretes ranging from 25 MPa to 55 MPa are called as standard concretes, while the strength of concretes above 55 MPa to 120 MPa known as HSC or high performance concrete(HPC). The strength of concretes above 120 or 150 MPa are named as ultra - high performance concrete(UHPC). HSC comprise plentiful advantage all over the world in large edifice, dams, bridges & buildings in violent environment. Usually, structure's components prepared by HPC will be closely reinforced. These types of dense reinforcements lead to severe harms during concrete placing. The heavy reinforced concrete troubles can be resolved by means of a concrete which is easy to place and can spread among the densely reinforced concrete structures.

In the recent years, self compacting concrete (SCC) has received large application for placing in densely reinforcement conditions with complicated placing circumstances. In favor of such uses, fresh concrete should have excessive fluidity & better cohesiveness. SCC is a concrete, which will flow & compacts by its self weight exclusive of segregation or bleeding. Normally, SCC has compressive strength in the range 60 to 100 N/mm^2. Although, lesser grades are to be determined and adopted depending on the obligation. At the time of 1980-90, the Japan researchers developed SCC for the very first time in university of Tokyo along with some of the top contractors in the industry. Since the durability of structures was fundamental concern in Japan, a sufficient compaction by experienced labors was crucial in seismic prone areas. As a result SCC was developed, which came into existence initially in 1989. Recently SCC was used for various applications in many of the countries for structural configurations which can offer superior operational surroundings with reduction of sound at the work. By using SCC, labor cost can be greatly reduced. SCC is a pioneering concrete which do not involve vibration for concreting. It is liable to compaction by its self load by filling the forms completely by achieving complete compaction in congested reinforcement which is homogenous and contains similar durable quality the same as conventional concrete.

In the production of SCC, a couple of varieties of SCC by various kinds of admixtures like fly ash, blast furnace slag, matakaolin & silica fume have been tried. The mineral

admixtures will be added to develop the distinct properties of concrete such as workability of concrete as well as sufficient compaction.

2. MATERIALS USED

2.1 Cement

Ordinary Portland Cement, (OPC) which is a 53 grade cement that confirms to Indian standard code IS:12269–1987 available in local market has been used in this study.

Table 1: Typical characteristics of cement

Sl. no	Tests Conducted on Cement	Results	Requirements as per is 12269:2013
1	Normal Consistency	32 %	28% - 34%
2	Initial setting time	45 min.	Not <30 min.
3	Final setting time	450 min.	Not >600 min.
4	Specific Gravity	3.10	2.95 – 3.15

2.2 Fly Ash

Powdered fuel ash (PFA) is used as a secondary cementitious material, obtained from RMC plant of VNC Private limited, Hiranandani villas, Devanahalli, which confirms to the Indian code IS: 3812 Part 1&2 – 2003 and the tests are done for as per the guidelines of the code IS: 1727 – 1967.

Table 2: Typical Properties of Fly Ash

Sl no	Tests on fly ash	Result	Permissible Values
1	Normal consistency	44%	-
2	Initial setting time	35 min.	not <30 min.
3	Final setting time	500 min.	not >600 min.
4	Specific gravity	2.40	1.85 – 2.85
5	Color	Brown	grey & brown (tan)

2.3 Ground Granulated Blast Furnace Slag (GGBS)

GGBS also used as tertiary cementitious material which is obtained from Power Tech RMC Shetterahalli, Devanahalli Taluk, confirming to the Indian code IS: 12089 – 1987.

Table 3: Physical Qualities of GGBS

Sl No	Tests Conducted on GGBS	Results	Permissible Values
1	Normal Consistency.	32%	-
2	Specific Gravity	2.90	2.85 – 2.95
3	Color	White	

2.4 Manufactured Sand (M.Sand)

Due to the scarcity of natural sand, many research works are being carried out for alternate materials to use as fine aggregates. Manufactured sand (M.Sand) confirming to Indian code IS: 383 – 1970 (Zone II), obtained from Bharathi Mines and Rocks Products Pvt. Ltd., is employed as a fine aggregate in this work.

Table 4: Physical Properties of M.Sand

Sl No	Tests Conducted On Fine Aggregate	Results
1	Material Type	M.Sand
2	Specific Gravity	02.60
3	Absorption Of Water	2.80%
4	Fineness Modulus	2.85

2.5 Coarse Aggregates

The coarse aggregates of size 12.5mm downsize are used in this work and it satisfies the specifications of IS: 383 – 1970. The tests were conducted as per the Indian code IS: 2386 Part – I.

Table 5: Physical Properties of Coarse Aggregates.

Sl. no	Tests conducted on CA	Result
1	Specific Gravity	2.54
2	Water Absorption (%)	0.8
3	Loose Bulk Density (Kg/m^3)	1441.70
4	Compacted Bulk Density(Kg/m^3)	1574.47

2.6 Water

Locally available potable water free all kinds of chemicals satisfying the requirements of Indian code IS: 456 – 2000 was used for preparing concrete.

2.7 Chemical Admixture

Admixtures are usually added to SCC to get good flowability and to make the concrete workable. To achieve high performance concrete, use of admixture is essential which will reduce the water-cement ratio. Hence the admixture used in this work is AURAMIX 300 PLUS provided from the FOSROC Pvt Ltd. The super-plasticizer is at a volume of 0.4% to total weight of the cementitious materials.

2.8 Glass Fiber

Glass fibers are used to improve the strength of the concrete by resisting the cracks that appear in the concrete. In this study glass fiber is added in 0%, 0.1% & 0.2% to the full volume of the concrete mix. The typical properties of glass fiber are given in the table below.

Table 6: Typical Properties of Glass Fiber

Sl No	Property	Results
1	Type of Glass Fiber	AR-Glass Fiber (Alkali Resistant)
2	Color	White
3	Length	12 mm
4	Diameter	14 μ

3. MIX DESIGN

A very simple and popular Nan Su method is used to develop M60 grade SCC. In this study, two different types SCC mixes were developed one is the conventional SCC & the other is the triple blended SCC. M60 grade mix quantities for both the mixes are given below.

3.1 Conventional SCC (CSCC)

Cement = 428.57 kg/m^3.
Fly Ash = 168.53 kg/m^3.
Fine Aggregate = 854.70 kg/m^3.
Coarse Aggregate = 681.203 kg/m^3.
Water = 214.956 kg/m^3.
Super plasticizer = 4 ml/kg of powder content.

3.2 Triple Blended SCC (TBSCC)

Cement = 428.57 kg/m^3.
Fly Ash = 92.21 kg/m^3.
GGBS = 92.21 kg/m^3.
Fine Aggregate = 854.70 kg/m^3.
Coarse Aggregate = 681.203 kg/m^3.
Water = 220.677 kg/m^3.
Super plasticizer = 4 ml/kg of powder content.

4. WORKABILITY TESTS ON FRESH CONCRETE

The self compacting concrete should exhibit the requirements specified in the EFNARC guidelines. Various types of workability tests are conducted on SCC in fresh state. In this study, Slump flow & T50 test, V-funnel and L-box tests are conducted to study the workability of SCC. The slump flow test is used to know the horizontal free flow of SCC without any kind of obstructions. The V-Funnel test is used to study the filling ability of concrete with a maximum size of coarse aggregates limiting to 20mm. L-Box test is done to know the passing ability of SCC between the reinforcing bars and other obstructions without segregation or any kind of blocking. The test conducted on slump flow, V-funnel and L-box are shown in figures 1, 2 & 3 respectively.

Fig 1: Slump flow test.

Fig 2: V-funnel test.

Fig 3: L-box test.

Table 7: Requirements of SCC as per EFNARC Guidelines

Sl No	**Properties**	**Unit**	**Permissible values**
1	Slump flow	mm	650 – 800
2	T_{50} Slump flow	sec	2 – 5
3	V-Funnel	sec	8 – 12
4	L-Box	-	0.8 – 1

Table 8: Workability Test Results

Sl No	Type of Mix	Slump Flow (mm)	T_{50} test (sec)	V funnel (sec)	L-box = (h2/h1)
1	CSCC	680	5	11	0.9
2	TBSCC	685	4	10	1.0

5. TESTS ON HARDENED CONCRETE

5.1 Compressive Strength Test

The cubes of size 150mm*150mm*150mm were casted and cured for a period of 7, 28 & 56 days for all the mixes. Three cube samples were tested in the compressive testing machine to get the average compressive strength of each mix. The test results are given table 9.

Table 9: Compressive Strength of SCC

Sl No	TYPE OF MIX	Compressive Strength (MPa)		
		7 Days	28 Days	56 Days
1	CSCC 0% GF	36.44	59.11	64.45
2	CSCC 0.1% GF	40.89	61.78	68.45
3	CSCC 0.2% GF	38.22	60.89	66.67
4	TBCSCC 0% GF	35.11	57.78	65.33
5	TBCSCC 0.1% GF	37.78	59.56	70.22
6	TBCSCC 0.2% GF	36.88	58.67	67.11

5.2 Split Tensile Strength Test

The cylinders of size 150mm dia and 300mm height were casted and cured for a period of 7, 28 & 56 days for all the mixes. Three cylinder samples were tested in the compressive testing machine to get the average split tensile strength of each mix.

Table 10: Split Tensile Strength of SCC

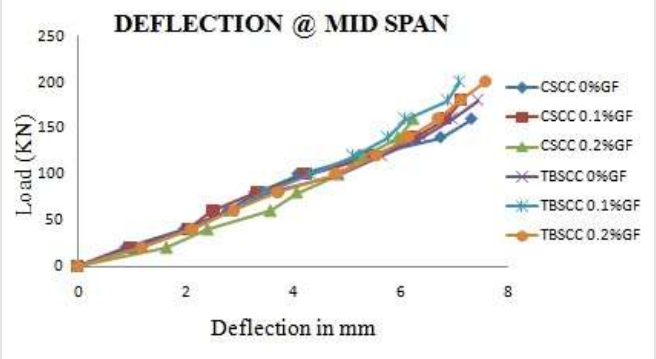
Sl No	TYPE OF MIX	Split Tensile Strength (MPa)		
		7 Days	28 Days	56 Days
1	CSCC 0% GF	2.90	4.98	5.41
2	CSCC 0.1% GF	3.19	5.67	6.10
3	CSCC 0.2% GF	2.98	5.41	5.70
4	TBCSCC 0% GF	2.70	4.84	5.69
5	TBCSCC 0.1% GF	2.95	5.55	6.41
6	TBCSCC 0.2% GF	2.77	5.29	5.98

5.3 Flexural Strength Test

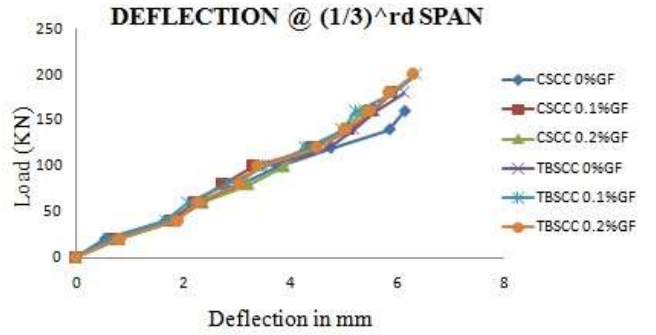
The beams of size 2000mm*250mm*150mm were casted and cured for a period of 28 days for all the mixes. The beam samples were tested in the loading frame to get the average ultimate load of each mix.

Table 11: Flexural behavior of RC Beams

MIX TYPE	Load (KN)		Ultimate load (KN)
	First Crack	Second Crack	
CSCC 0% GF	125	131	160
CSCC 0.1% GF	127	150	193
CSCC 0.2% GF	129	152	171
TBSCC 0% GF	122	154	185
TBSCC 0.1% GF	131	173	219
TBSCC 0.2% GF	130	170	204



Graph 1: Load vs Deflection @ mid span



Graph 2: Load vs Deflecction @ $(1/3)^{rd}$ Span

6. CONCLUSION

From the obtained test results, the following conclusions were made.

1. The triple blended SCC exhibits good workability properties compared to conventional SCC. This is due to the higher content of finer particles such as fly ash & GGBS along with cement.
2. From the flexural test results of reinforced concrete beams, it can be concluded that the load carrying capacity of triple blended SCC is more than that of conventional SCC.
3. Also, it can be concluded that manufactured sand can be used as a alternate material for river sand.
4. The results of compressive strength, split tensile strength & flexural strength exhibits the optimum dosage of glass fiber that can be used is 0.1% to the total volume of the mix.

5. Finally from this experimental work, it may be concluded that the use of industrial by-products such as fly ash & GGBS has vast advantage making the environment eco-friendly.

SCOPE FOR FUTURE STUDY

1. To study the mechanical properties of high strength SCC using other alternate cementitious materials at different percentages.
2. Use of various types of fibers to determine the performance of SCC for various proportion of addition.
3. Study the mechanical properties of SCC for higher grade of concrete.
4. To study the behavior of reinforced SCC of beams under various loading conditions

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