EFFECT OF GLASS FIBERS ON SELF-COMPACTING CONCRETE

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ABSTRACT

Self-Compacting Concrete (SCC) is a highly workable concrete that can flow throw densely reinforced or complex structural elements under its own weight and adequately fill voids without segregation or excessive bleeding without the need for vibration. Concrete is strong in compression but weak in tension. To make it strong in tension discontinuous Anti-Crack high Dispersion glass fibers are added to it. SCC made with addition of discontinuous glass fibers is called as Glass Fiber reinforced Self Compacting Concrete (GFRSCC). In this paper an experimental study has been carried out to check the effect of Anti-Crack high Dispersion glass fibers on the compressive strength, split tensile strength and flexural strength of SCC.

The results shows that, as compared to the Normal SCC, the compressive strength of GFRSCC increases by 2.80% and 12.42%, the split tensile strength of GFRSCC increases by 4.47% and 25.12% and the flexural strength of SCC increases by 6.57% and 14.34% when the Cem-FIL Anti-Crack HD glass fibers were added at 0.25% and 0.50% respectively by the weight of total cementitious material contents in that particular mix design data. The addition of 0.25% Cem-FIL Anti-Crack HD glass fibers to SCC has not much affect on the workability of Normal SCC. The addition of 0.50% Cem-FIL Anti-Crack HD glass fibers affects the workability of SCC to some extent.

Keywords: *SCC, GFRSCC, Cem-FIL Anti-Crack HD glass fibers.*

1. INTRODUCTION:

1.1 SCC has proven itself a big milestone in the construction industry because of its various advantages. It can pass through congested reinforcement and the gap between formwork and steel reinforcement and fill the formwork without any voids. The heavy and dense reinforcement can raise problems of pouring and compacting the concrete. The concrete must be able to pass the dense rebar arrangement without blocking or segregating. Poor placement and the lack of good compaction can lead to the inclusion of voids and loss of long term durability of concrete structures. To avoid this concrete which flow itself and fill all the spaces should be used. This need has been solved by use of self-Compacting concrete. SCC has various advantages over normal vibrated concrete as it doesn't need vibration so; the reduction in noise at the site is achieved. It gives better surface finish. Due to having higher flow values it can be easier to place SCC this reduces the number of workers on site. It speeds up the construction that means economy is achieved. SCC needs more amount of paste content. So that to achieve economy the cement is replaced in some percentages by cement replacement materials like fly ash, GGBS, silica fumes[1,2,3].

The necessity of SCC was proposed by Okamura in 1986 to overcome the problem of reduced skilled workers in Japan around 1980's. Any concrete which is said to be SCC has to posses three properties in its fresh state as filling ability, passing ability and segregation resistance. The mechanism to achieve self-compatibility is achieved by limiting coarse aggregate content, reduced water-powder ratio and use of super plasticizer[1,2]. The various tests to check the fresh properties of SCC given by EFNARC are Slump flow test, T_{50} slump flow, L-box test, V-funnel test and V-Funnel at T_5 minutes[3].

Though concrete possesses high compressive strength two characteristics have limited their uses that are brittle and weak in tension. However the development of fiber-reinforced composites (FRC) has provided a technical basis for improving these deficiencies. Fibers are small pieces of reinforcing material added to a concrete mix which normally contains cement, water and fine and coarse aggregate. Among the more common fibers used are steel, glass, asbestos and polypropylene. When the loads imposed on concrete approach that for failure cracks will propagate, sometimes rapidly; fibers in concrete provide a means of arresting the crack growth. If the modulus of elasticity of the fiber is high with respect to the modulus of elasticity of the concrete or mortar binder, the fibers help to carry the load, thereby increasing the tensile strength of the material. Fibers improve the toughness, the flexural strength, reduces creep strain and shrinkage of concrete.

The Cem-FIL Anti-Crack High Dispersion glass fibers have various improved properties. The addition of discontinuous Cem-FIL Anti-Crack High Dispersion glass fibers to the normal SCC increases its toughness, young's modulus, flexural strength, compressive strength and split tensile strength. The GFRSCC has increased energy absorption capacity compared to the normal SCC. The addition of glass fibers also increases the ductility of the concrete[5,7,12]. Addition of glass fibers can control the cracking produced due to very early age shrinkage on both standard concrete and SCC in two different ways by reducing the total cracked area and the maximum length of the crack[4]. And importantly the addition of glass fibers to SCC does not affect on its workability requirements. The glass fibers also reduce the segregation and bleeding of the GFRSCC[5].

In the present work, the effect of Cem-FIL Anti-Crack High Dispersion glass fibers on the fresh and hardened properties of SCC are investigated.

1.2 Literature Review

Okamura proposed the concept of SCC in 1986. Till today there is lot of research work has been done and in progress to develop the better and economical SCC and GFRSCC. The most work has been done in the countries like Japan, USA where the construction industry has crossing and achieving new heights everyday. Some of the literature available on SCC was referred and produced in this paper as follows:

Nan Su et al. [5] have studied to carry out a new mix design method for SCC. This Nan Su method of mix design was simple, easy to implement, less time-consuming, it requires smaller amount of binders and hence saves cost compared to the method of Japanese Ready Mixed Concrete Association. In this design methodology Packing Factor (PF) term was used which was defined as the ratio of mass of aggregate of tightly packed state in SCC to that of loosely packed state in air. A higher PF value would imply a greater amount of coarse and fine aggregates used, thus, decreasing the content of binders in SCC. Consequently, its flowability, self-compacting ability and compressive strength will be reduced. On the other hand, a low PF value would mean increased dry shrinkage of concrete which results, more binders were required, thus, raising the cost of materials. In addition, excess binders used would also affect the workability and durability of SCC. Therefore, it was important to select the optimal PF value in the mix design method so as to meet the requirements for SCC properties and at the same time taking economy into considerations. In this research paper, the authors have modified a new mix design methodology. In this method of mix design, the fine aggregate content was more than that of coarse aggregate. The volume ratio of fine aggregates to total aggregates was between 50 % to 57% which increases the passing ability. The contents of cement, fly ash, GGBS, sand, coarse aggregate and superplasticizer were calculated from the equations they have derived for the mix design procedure. The SCC was made using all these materials. The workability tests were carried out on the fresh SCC. They carried out the compressive strength test on the cylinders and the results shows that as packing factor increases the compressive strength decreases. For smaller PF values, there was more paste volume in SCC and which increases the compressive strength. From this experimental research they came on the conclusions that, by adjusting the packing factor values in the range 1.18, 1.16, 1.14, 1.12 the medium compressive strength SCC from 27.5 MPa to 48 MPa can be achieved. They suggest, the water required by this method was in the range of 170-176 litter/m^3, the cement content needed was 200-350 kg/m^3 which was very economical. The total binder content used in this research work was 424 kg/m^3 which was less than the Japanese mix design method requirement of 500 kg/m^3. The findings of their research paper was this mix design method was economical than that of Japanese Mix Design Method as the materials required for making the SCC by Nan Su method were less in amount.

J. K. Su et al. [6] have studied the effect of sand ratio (S/A ratio), fine aggregate volume to total aggregate volume, on the elastic modulus of self-compacting concrete. They made cement paste cylindrical specimens using Portland cement, slag, fly ash, water and superplasticizer. For concrete specimens they made cylinders with ASTM Type I Portland cement, slag, fly ash, superplasticizer, water, fine aggregate and coarse aggregate. The different S/A ratios used were 0.3, 0.4, 0.45, 0.475, 0.5, 0.525, and 0.55. The elastic moduli and compressive strengths of the specimens were measured. They carry out slump flow test, slump test, and box test to evaluate concrete flowability. Experimental programme was carried out by them and they got the results that the flowability of SCC increases with an increase in S/A ratio. The S/A ratio was an important material parameter of SCC and the rheological properties increase with an increase in the S/A ratio. The proper S/A ratio for SCC was suggested to be 47.5%. The elastic modulus of concrete was influenced mainly by the elastic properties of matrix, fine aggregate and coarse aggregate. If, the elastic moduli of fine aggregate and coarse aggregate were not much different and the total volume of aggregate was constant, the elastic modulus of SCC was not significantly affected by S/A ratio.

T. Suresh Babu et al. [10] carried out an experimental work to check the effect of Cem-FIL Anti-Crack High Dispersion glass fibers to self-compacting concrete. For mechanical properties and stress-strain behaviour of self-compacting concrete and glass fibre reinforced self-compacting concrete, they made a strength based mix proportion of self-compacting concrete based on Nan-Su method of mix design and the proportion was fine-tuned by using Okamura's guidelines. Five SCC Mixes with different types of admixtures were developed in the laboratory and Cem-FIL Anti-Crack High Dispersion glass fibres of 600 grams/m^3 of concrete were added to these SCC mixes and glass fibre reinforced self- compacting concrete was developed. In experimental programme they carried out casting and testing of SCC and GFRSCC elements, 3 specimens each for each mix of SCC and GFRSCC, in compression, tension and in flexure. After testing the specimens they found that the GFRSCC mixes compared to normal SCC mixes have shown an improvement in compressive strength by 2.0 to 5.5%, the split tensile strength and flexural strengths by 3.0 to 7.0 % and 11.0 to 20.0 % respectively, the Young's modulus by 14%, Energy absorption capacity by 30%, improvement of ductility at 90%, 80% and 70% stress levels was 21%, 25% and 27% respectively.

M Chandrasekhar et al. [11] studied the Stress-Strain behaviour of GFRSCC under axial compression. Their work concentrates on the stress-strain behaviour of M50 grade GFRSCC under confined and unconfined states with different percentages of confinement in the form of circular steel hoops. They took the experimental programme in two phases. In the first phase M50 grade self-compacting concrete was made with and without glass fibers to satisfy the fresh and hardened properties. In the second phase the mechanical behaviour of hardened GFRSCC was studied under different percentages of confinements in the form of hoops. They proposed two analytical models for different confinements ranging from 0 to 1.591 percent volume confinement in the form of circular hoops. In the analytical programme the stress-strain results under axial compression for different levels of confinement, mathematical models were developed and compared. Standard cubes of 100 mm x 100 mm x 100 mm and cylinders of 150 mm diameter and 300 mm length were cast for studying the compressive strength and stress-strain behaviour of concrete. The cylinder specimens were cast without any confinement and with different percentages of confinement in the form of hoops. The specimens cast were cured for 28 days and tested as per BIS specifications. The cylinder specimens were tested in 1000 kN strain control Universal Testing Machine under 0.02 mm/sec strain rate. The results show that the confinement of the concrete was increased the 28 days strength from 7.25% to 44.30% for different percentages of confinements. There was an increase in the value of secant modulus (E) for M50 grade GFRSCC with confinement.

2. MATERIAL AND METHODS

2.1 Materials used for SCC and GFRSCC

The ingredients used for making the SCC and GFRSCC are as follows-

2.1.1 Cement:

The Ordinary Portland Cement (OPC) of 53 grade (Ambuja Cement) having specific gravity of 3.15 was decided to use in this study. It was tested for its physical properties in accordance with Indian Standard specifications.

2.1.2 Fly Ash

Locally available fly ash confirming to IS: 3812-2003.

2.1.3 GGBS

GGBS confirming to IS: 12089-1987 having the surface area about 350 to 450 m^2/ kg was used.

2.1.4 Fine Aggregate

Natural River Sand , clear from all sorts of organic impurities was used. The fine aggregate passing through 4.75 mm sieve and having specific gravity of 2.70 and confirming zone II were used.

2.1.5 Coarse Aggregate

Crushed granite angular aggregates passing from 12.5 mm sieve and confirming to IS: 383 and having specific gravity of 2.74 was used.

2.1.6 Water

Potable water is generally considered satisfactory for mixing concrete. Water is free from acids, oils, alkalis, vegetables or other organic impurities. Ordinary tap water was used for concrete manufacturing in this work.

2.1.7 Superplasticizer

The superplasticizer Conplast SP 430 confirming to IS: 9103-1999 having specific gravity of 1.1 to 1.2 was used in this study.

2.1.8 Viscosity Modifying Agent

VMA- Mastermatrix 2 (Glenium Stream 2) having specific gravity of 1.19 was used in this study.

2.1.9 Glass Fibers

Cem-FIL Anti-Crack HD glass fibers were used for this experimental study (Table 1).

Table 1. Properties of Cem-FIL Anti-Crack HD Glass Fibers

Sr. No.	Property	Typical Value
1	Number of Fibers	214 millions/kg
2	Aspect Ratio	857: 1
3	Specific Surface Area	150 m^2/kg
4	Tensile Strength	1700 MPa
5	Modulus of Elasticity	72 GPa
6	Corrosion Resistance	Very High
7	Specific Gravity	2.68
8	Density	26 kN/m^3

9	Filament Diameters	14 microns
10	Filament Length	12 mm

2.2 Mix Design Procedure for Normal SCC and GFRSCC

There is no standard method for SCC mix design and many academic institutions, admixture, ready-mixed, precast and contracting companies have developed their own mix proportioning methods [9]. There were many proposed methods exist for the proportioning of SCC but most of which give only general guidelines and ranges of quantities of materials to be used in proportioning SCC. In this present study the mix design of SCC was made making the modifications in the mix design of NVC made by using the IS 10262: 2009. Firstly, as per IS 10262: 2009, mix design of normal M30 grade concrete was made. Then that mix design was modified for SCC by using EFNARC guidelines and literature review study. Many trial mix designs were made and tested for fresh properties of SCC till satisfactory results were achieved. The proportion of ingredients for M30 Grade SCC was given below in Table 2,

Table 2. Proportion of Ingredients of SCC for M30 Grade

Sr. No.	Ingredients of SCC	Proportion by Weight of Cement	Quantity in (kg/m^3)
1	Cement	1	325.68
2	Fly Ash	0.3571	116.315
3	GGBS	0.0714	23.263
4	Fine Aggregate	3.1066	1011.77
5	Coarse Aggregate	2.8421	794.96
6	Water	0.5428	176.8
7	Superplasticizer	0.0357	11.63
8	VMA	0.0049	1.62

2.2.1 Mix Design Procedure for GFRSCC [21]

For making GFRSCC, the Cem-FIL Anti-Crack HD glass fibers were added in the SCC mix. The Anti-Crack HD glass fibers were added to the SCC at different percentages by the weight of total cementitious materials content . The Cem-FIL Anti-Crack HD glass fibers were added in two different percentages by the weight of total cementitious materials content to study the fresh and hardened properties of SCC. The percentages selected were 0.25% and 0.50% by the weight of total cementitious materials. The GFRSCC made with the addition of 0.25% and 0.50% of Cem-FIL Anti-Crack HD glass fibers were called as 0.25% GFRSCC and 0.50% GFRSCC respectively.

2.2.1.1 Mix Design Procedure for 0.25% GFRSCC

The mix design data of Normal SCC was taken. For making 0.25% GFRSCC, at the time of casting the 0.25% Cem-FIL Anti-Crack HD glass fibers by the weight of total cementitious materials were added in the wet mix. The fresh properties of the 0.25% GFRSCC were carried out as per the workability tests given by EFNARC guidelines. The workability tests performed were Slump flow by Abram's cone, T_{50cm} slump flow, L-box test, V-funnel test and V-funnel at $T_{5\ minutes}$ test. The flow tests values were satisfying the EFNARC guidelines. So, the mix design data for the 0.25% GFRSCC was finalised. It was same as that of Normal SCC mix design data.

2.2.1.2 Mix Design Procedure for 0.50% GFRSCC

To make the 0.50% GFRSCC, the mix design data of Normal SCC was taken and the 0.50% Cem-FIL Anti-Crack HD glass fibers by the weight of total cementitious materials were added in the wet mix. Again, the fresh properties of the mix were carried out and it was found that the workability is affected in some extent by the addition of 0.50% glass fibers. So, to achieve the workability requirements the superplasticizer dose was increased from 2.5% to 2.55% keeping the VMA dose constant as in the Normal SCC mix design. The 0.50% GFRSCC was cast using this new mix design data and the workability tests were carried out. The 0.50% GFRSCC with this new mix design data satisfies the fresh properties criterion and hence the mix design data for the 0.50% GFRSCC was finalised.

Table 3: Mix Design Data for Different GFRSCC Mixes of M30 grade

Sr. No.	Ingredients of GFRSCC	Unit	Quantity of Ingredients of Diff. GFRSCC Mixes	
			For 0.25% GFRSCC	For 0.50% GFRSCC
1	Cement	kg/m^3	325.68	325.68
2	Fly Ash	kg/m^3	116.315	116.315
3	GGBS	kg/m^3	23.263	23.263
4	Fine Aggregate	kg/m^3	1011.77	1011.77
5	Coarse Aggregate	kg/m^3	794.96	794.96
6	Water	Liter/m^3	176.8	176.8
7	Superplasticizer	kg/m^3	11.63	11.86
8	VMA	kg/m^3	1.62	1.62
9	Cem-FIL Anti-Crack HD Glass Fibers	kg/m^3	1.163	2.326

2.3 Specimen Preparation

Three cubes of sizes 150×150×150 mm, three cylinders of sizes 100 mm diameter and 200 mm height and three beams of sizes 100×100×500 mm were cast for each mix design of Normal SCC and GFRSCC. To test the effect of anti-crack HD glass fibers on the compressive strength, split tensile strength and on flexural strength of the SCC, it was decided to cast three cubes, three cylinders and three beams for each mix design of Normal SCC and GFRSCC. The cubes of sizes 150×150×150 mm, cylinders of 100 mm diameter and 200 mm height and beams of sizes 100×100×500 mm were to be cast resp. A total of 15 cubes, 15 cylinders and 15 beams were to be cast. As the SCC mix was ready, the freshly made SCC was filled in the moulds of cubes, cylinders and beams with the help of a pan to achieve a smooth and continuous flow of SCC in the moulds. After the moulds were filled completely the upper surface were made plane with the help of trowel.

2.4 Curing of Specimen

The cast specimen of SCC and GFRSCC were left for 20 hours and de-moulded after 20 hours as the surface of the SCC can dry quickly because of the increased quantity of paste, the low water/fines ratio and the lack of bleed water at the surface. Therefore, initial curing should be done at early time than done for normal concrete in order to minimize the risk of surface crusting and shrinkage cracks caused by early age moisture evaporation.[7]. The specimens were kept in the water curing tank for 28 days of water curing.

3. RESULTS AND ANALYSIS

The workability tests were carried on the Normal SCC and GFRSCC mixes. The results of the workability tests were presented in this chapter. The cubes, cylinders and beams cast of Normal SCC and GFRSCC mixes were tested for the compressive strength, split tensile strength and flexural strength respectively. The results of the strength tests and analysis of the results are given below-

3.1 Fresh Properties of Normal SCC and GFRSCC Mixes

The workability tests were taken on the fresh Normal SCC and GFRSCC. The fresh properties of Normal SCC and GFRSCC with the different workability tests and its values are given in Table 4 below:

Table 4. Fresh Properties of Normal SCC and GFRSCC Mixes

Sr. No	Mix Designation	Slump Flow Test		L-Box Test	V-Funnel Test	
		Horizontal Flow in mm	T_{50cm} time in sec		Time for complete discharge in sec	T_5 minutes in sec
1	Normal SCC	689	3	0.86	8	9
2	0.25% GFRSCC	681	4	0.85	9	10
3	0.50% GFRSCC	676	4	0.84	9	11

4.3 Hardened Properties of SCC and GFRSCC

The hardened concrete properties of Normal SCC and GFRSCC mixes such as compressive strength, split tensile strength and flexural strength were studied in this work. The effect of addition of Cem-FIL Anti-Crack HD glass fibers on the hardened properties of Normal SCC and GFRSCC were carried out here. The hardened concrete properties and the results of the tests on hardened Normal SCC and GFRSCC mixes were as follows:

4.3.1 Compressive Strength

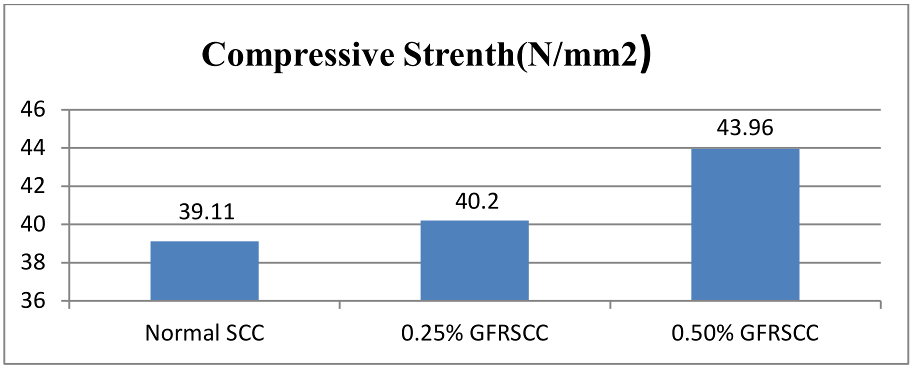
The compressive strength tests on the standard cubes made of the Normal SCC and GFRSCC mixes were tested in CTM and the ultimate load was recorded. The compressive strength were calculated and the average values of compressive strengths of each three cubes made with the Normal SCC and GFRSCC mixes were given in Table 5:

Table 5: Compressive Strength of Normal SCC and GFRSCC Mixes after 28 days

Sr. No.	Mix Designation	Ultimate Compressive Load (kN)	Compressive Strength (N/mm^2)	% Increase in Compressive Strength
1	Normal SCC (0% GFRSCC)	880.12	39.11	-
2	0.25% GFRSCC	904.614	40.20	2.80
3	0.50% GFRSCC	989.267	43.96	12.42

From the above table it was seen that the compressive strength of GFRSCC was increasing as the Cem-FIL Anti-Crack HD glass fibers were added to SCC. The rate of increase of compressive strength was increasing upto 0.50% addition of Cem-FIL Anti-Crack HD glass fibers.

The comparison of the compressive strength of Normal SCC and GFRSCC mixes at various percentages of Cem-FIL Anti-Crack HD glass fibers is as shown in Bar Chart 1:



Bar Chart 1: Compressive Strength vs. % of Cem-FIL Anti-Crack HD Glass Fibers

The bar chart shows that, after the addition of Cem-FIL Anti-Crack HD glass fibers, the compressive strength of SCC increases. For 0.25% and 0.50% addition, the compressive strength was increasing continuously.

4.3.2 Split Tensile Strength

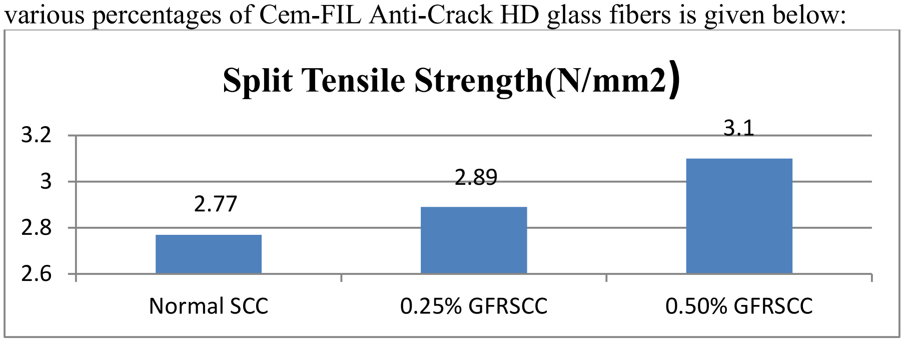
The split tensile strength test was carried on the cylinders made of Normal SCC and GFRSCC. The split tensile strength of cylinders with Normal SCC and GFRSCC was as shown in Table 6-

Table 6: Split Tensile Strength on Cylinders after 28 days

Sr. No.	Mix Designation	Ultimate Load (kN)	Split Tensile Strength (N/mm^2)	% Increase in Split Tensile Strength
1	Normal SCC (0% GFRSCC)	87.281	2.77	-
2	0.25% GFRSCC	90.981	2.89	4.47
3	0.50% GFRSCC	97.757	3.10	12.25

The results shows that, after addition of the Cem-FIL Anti-Crack HD glass fibers to the SCC, the split tensile strength increase as the percentages of glass fibers increases.

The Bar chart showing the results of split tensile strength of Normal SCC and GFRSCC mixes at various percentages of Cem-FIL Anti-Crack HD glass fibers is given below:



Bar Chart 2: Split Tensile Strength vs. % of Cem-FIL Anti-Crack HD Glass Fibers

The bar chart 2 shows that, the addition of Cem-FIL Anti-Crack HD glass fibers to SCC increases the split tensile strength.

4.3.3 Flexural Strength

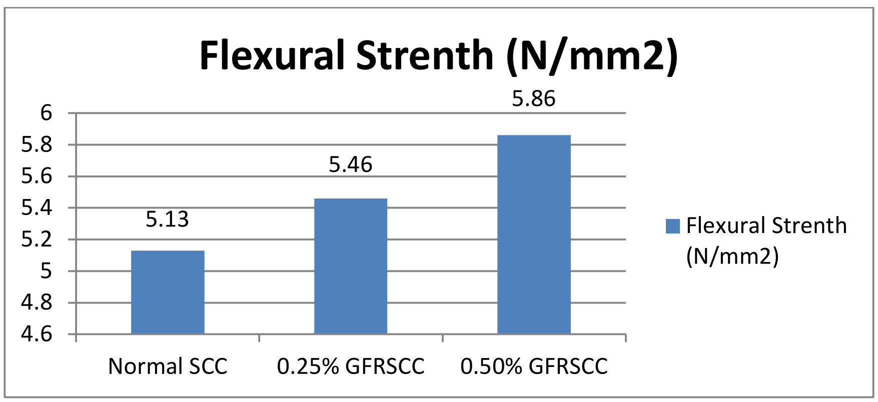
The flexural strength was carried on the beams made of Normal SCC and GFRSCC mixes. The flexural strength is as shown in Table 7:

Table 7: Flexural Strength on Beams after 28 days

Sr. No.	Mix Designation	Ultimate Load (kN)	Flexural Strength (N/mm^2)	% Increase in Flexural Strength
1	Normal SCC (0% GFRSCC)	12.824	5.13	-
2	0.25% GFRSCC	13.667	5.46	6.57
3	0.50% GFRSCC	14.664	5.86	14.34

From the above Table 7 it was seen that after addition of Cem-FIL Anti-Crack HD glass fibers to SCC the flexural strength increases as the percentages of glass fibers increases.

The Bar chart showing the results of flexural strength of Normal SCC and GFRSCC mixes at various percentages of Cem-FIL Anti-Crack HD glass fibers is given below:



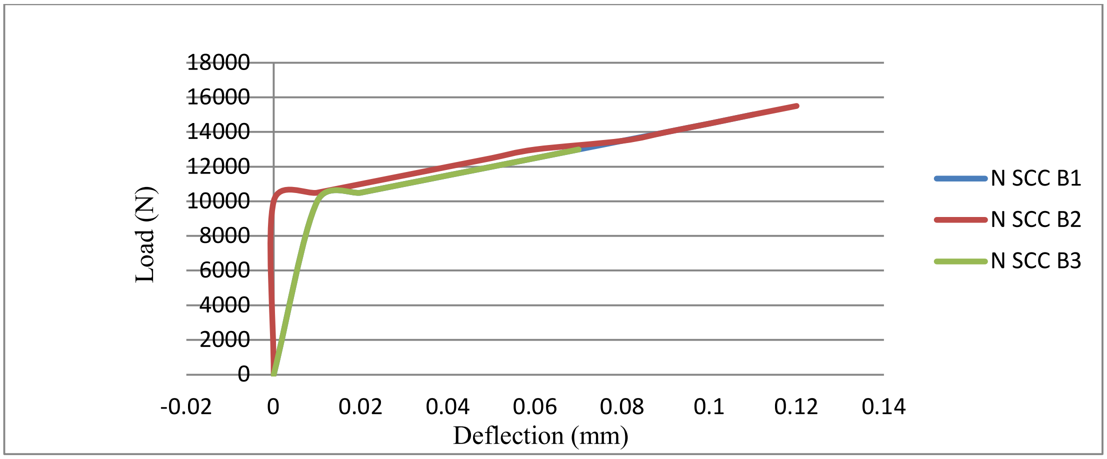
Bar Chart.3: Flexural Strength vs. % of Cem-FIL Anti-Crack HD Glass Fibers

The bar chart 3 shows that, the addition of Cem-FIL Anti-Crack HD glass fibers to SCC increases the flexural strength. The flexural strength was maximum for the 0.5% addition of Cem-FIL Anti-Crack HD glass fibers.

5. Load vs. Deflection

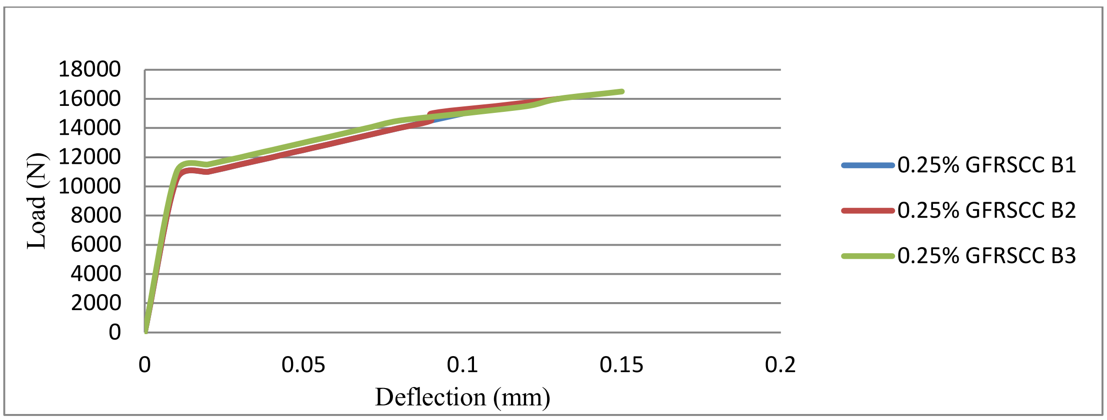
The ultimate load at the time of flexural strength test on beams of Normal SCC and GFRSCC were recorded. The deflections of the beam were recorded on the dial gauge. The loads vs. deflection graph for the beams of Normal SCC and GFRSCC mixes are as shown below:

Load vs. Deflection for Normal SCC Beams



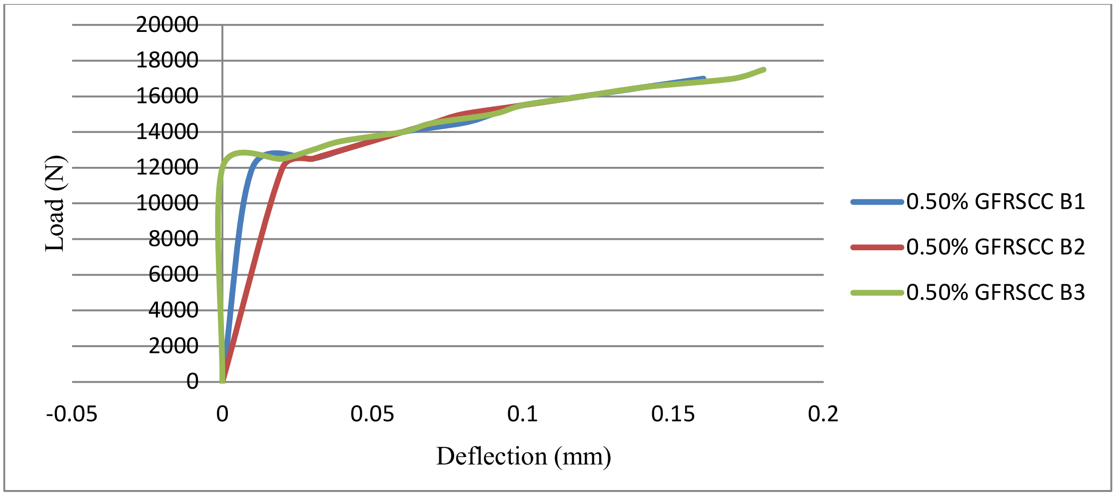
By observation,tThere was no propagation of cracks and all the three beams fail suddenly. This shows the Normal SCC has brittle failure.

Load vs. Deflection for 0.25% GFRSCC Beams



By observation, this indicates that, after the addition of Cem-FIL Anti-Crack HD glass fibers, the load carrying capacity of beams increases compared to Normal SCC beams. Propagation of cracks was observed in these beams which mean the beams shows ductile failure.

Load vs. Deflection for 0.50% GFRSCC Beams



By observation, this indicates that, the load carrying capacity of 0.50% GFRSCC beams was more than 0.25% GFRSCC beams and Normal SCC beams. Propagation of cracks was observed in these beams which mean the beams shows ductile failure.

4. CONCLUSIONS

From the experimental work carried out the following conclusions were made:

1) The compressive strength of GFRSCC increases by 2.80% and 12.42%, as compared to the compressive strength of Normal SCC, when the Cem-FIL Anti-Crack HD glass fibers were added at 0.25% and 0.50%, respectively by the weight of total cementitious material contents in that particular mix design data.
2) The split tensile strength of GFRSCC increases by 4.47% and 25.12% as compared to the split tensile strength of Normal SCC, when the Cem-FIL Anti-Crack HD glass fibers were added at 0.25% and 0.50% respectively by the weight of total cementitious material contents in that particular mix design data.
3) The flexural strength of SCC increases by 6.57% and 14.34% as compared to the flexural strength of Normal SCC, when the Cem-FIL Anti-Crack HD glass fibers were added at 0.25% and 0.50% respectively by the weight of total cementitious material contents in that particular mix design data.
4) For better and homogeneous mixing of Cem-FIL Anti-Crack HD glass fibers in the SCCthe fibers were added in the wet mix after the addition of VMA.
5) The addition of 0.25% Cem-FIL Anti-Crack HD glass fibers to SCC has not much affect on the workability of Normal SCC. The addition of 0.50% Cem-FIL Anti-Crack HD glass fibers affects the workability of SCC to some extent.

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