Performance of Glass Fibre Reinforced Self Compacting Concrete

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***Abstract* – Self Compacting Concrete has developed as an advanced material, proficient of attaining remarkable development in the arena of concrete technology. "Glass Fibre Reinforced Self Compacting Concrete" (GFRSCC) is composed of cement, different sizes of coarse and fine aggregates, which integrate with distinct, uneven glass fibres". Glass fibres control the cracking in concrete caused by drying and plastic shrinkage. Uniformity, surface integrity of the concrete enhanced and possibility of cracks get reduced due to the decrease in bleeding. In this current investigation, M40 grade Self Compacting Concrete reinforced with glass fibres has been developed using Nan Su method. Fresh state and Hardened state properties of GFRSCC are studied for glass fibres of different aspect ratio (875, 1285 & 1714) and percentage of volume fraction (0, 0.25, 0.5, 0.75 & 1). From the investigation carried out it is found that incorporation of glass fibres of aspect ratio 1285 and percentage of volume fraction 0.5 to SCC attains better compressive and flexural strength compare to other mixtures and also incorporation of glass fibres of aspect ratio 1285 and percentage of volume fraction 0.75 to SCC attains better split tensile strength compare to other mixtures.**

***Index Terms* – Self Compacting Concrete, Glass Fibres, Fresh and Hardened Properties.**

I. INTRODUCTION

Self Compacting Concrete is a concrete which compacted under its own weight. Self Compacting Concrete is not influenced through the profile and quantity of reinforcement or else the arrangement of a pavement and structures, the abilities of labors, owing to its hindrance to segregation and more fluidity, SCC can be driven extended distances. SCC has developed as an advanced material, proficient of attaining remarkable development in the arena of concrete technology. For SCC, no need vibration which can flow on all sides of obstacles, fill up the formwork entirely and condense the reinforcement. Self Compacting Concrete had better enriched durability and strength related to orthodox concrete, because of inferior W/C and greater content of cementitious constituents. Also Self Compacting Concrete has a brittle characteristic even with other kinds of cementitious materials. "Glass Fibre Reinforced Self Compacting Concrete" (GFRSCC) is composed of cement, different sizes of coarse and fine aggregates, which integrate with distinct, uneven glass fibre". Due to the incorporation of glass fibres in Self Compacting Concrete brittle characteristic can be enriched. There is an improvement in inhibition or switch origination, promulgation, or combination of cracks and mechanical properties of concrete due to arbitrarily leaned distinct fibres since the concrete is brittle when subjected to tensile loading. Based on the characteristics of the fibres and concrete, performance and characteristics of concrete reinforced with fibres varies. Volume fraction, Geometry, Direction, and Dispersion of the fibres are the significant characteristics of fibres. The objectives of this study is to produce M40 grade Self Compacting Concrete using the Nan Su mix design procedure. To investigate the fresh and hardened properties of Self Compacting Concrete with and without glass fibres. The variants in this investigation are percentage of volume fraction (0, 0.25, 0.5, 0.75 and 1) and aspect ratio (875, 1285 and 1714).

II. MATERIALS

Cement

Cement used for our research is OPC (43 grade) of Chettinad cement confirmed to the typical specifications of IS: 8112-2013 is used. The specific gravity of the cement was 3.14. The normal consistency, initial setting time and final setting time were 31%, 53 minutes and 362 minutes respectively.

Fine Aggregate

Locally available M-sand passing through 1.18mm sieve was used for all of the mixes of SCC. The aggregates used were in compliance to zone II according to IS: 383-1970. The specific gravity of the fine aggregate was 2.5. The packing factor, water absorption and loose bulk density were 1.194, 0.9% and 1320 kg/m^3 respectively.

Coarse Aggregate

In the vicinity obtainable crushed granite aggregate sieved through 12.5mm and retaining on 4.75mm was used for all of the mixes of Self Compacting Concrete. The aggregates used were conforming to IS: 383-1970. The specific gravity of the coarse aggregate was 2.6. The packing factor, water absorption and loose bulk density were 1.146, 0.3% and 1280 kg/m^3 respectively.

Flyash

Class F flyash from Raichur Thermal Power Plant was used as cement replacement material for SCC mixes in this investigation. The specific gravity of the fly-ash used was 2.24.

Glass Fibres

In this investigation glass fibres are of Cem-Fil Anti-Crack Alkali-Resistant High Dispersion of aspect ratio 875, 1285 and 1714 are made use to enhance strength and durability of SCC. The diameter, specific gravity and elastic modulus of glass fibres are 14µ, 2.68 and 72 Gpa.

III. EXPERIMENTAL WORK

Mix Proportions

After having the mix design procedures, in the present investigation, a number of trail mix designs were conducted to finalize a suitable mix proportioning to cast the cubes, cylinders and prisms.

Table 1 Trail Mix Proportions of SCC

Mix ID	Cement (kg/m^3)	Flyash (kg/m^3)	C.A (kg/m^3)	F.A (kg/m^3)	W/P	Water (l/m^3)	SP (%)
TM_1	286	272	660	867	0.3	163	1.5
TM_2	286	272	660	867	0.3	163	1.7
TM_3	286	272	660	867	0.3	163	1.6

Table 2 Fresh Properties of Trial mixes

Trail mixes	Slump flow		J-Ring(mm)	U-Box(mm)	V-funnel	
	Dia(mm)	T_{50}(sec)			T(sec)	T_{5min}(sec)
TM_1	654	5	9	26	11	2.6
TM_2	700	3	6	8	8	1.8
TM_3	682	4.3	7	16	10	2.1

Cubes are casted corresponding to these three trail mixes for 7 and 28 days and then tested. Based on fresh and hardened properties results obtained, TM_2 is selected.

In this investigation thirteen concrete mixtures are prepared as shown in the following table.

Table 3 Mixture Proportions

Mix ID	Aspect ratio	Volume fraction	Cement (kg/m^3)	Flyash (kg/m^3)	C.A (kg/m^3)	F.A (kg/m^3)	W/P	Water (l/m^3)	SP (%)
A_0V_0	0	0	286	272	660	867	0.3	163	1.5
A_1V_1	875	0.25	286	272	660	867	0.3	163	1.5
A_1V_2	875	0.5	286	272	660	867	0.3	163	1.5
A_1V_3	875	0.75	286	272	660	867	0.3	163	1.5
A_1V_4	875	1	286	272	660	867	0.3	163	1.5
A_2V_1	1285	0.25	286	272	660	867	0.3	163	1.5
A_2V_2	1285	0.5	286	272	660	867	0.3	163	1.5
A_2V_3	1285	0.75	286	272	660	867	0.3	163	1.5
A_2V_4	1285	1	286	272	660	867	0.3	163	1.5
A_3V_1	1714	0.25	286	272	660	867	0.3	163	1.5
A_3V_2	1714	0.5	286	272	660	867	0.3	163	1.5
A_3V_3	1714	0.75	286	272	660	867	0.3	163	1.5
A_3V_4	1714	1	286	272	660	867	0.3	163	1.5

Preparation and Casting of test specimens

In case of mixing for self-compacting concrete, all the ingredients cement, flyash, fine and coarse aggregate were initially mixed in dry condition in the concrete mixer for one minute. After that fibres were added and mixed thoroughly for getting uniform mix. Formerly 70% of estimated quantity of water was poured to the dry mix and mixed systematically for one minute. The remaining 30% of water was mixed with the super-plasticizer and was added into the mixer and mixed for five minutes.

Cube moulds of 150x150x150mm were used to cast cube specimens. In order to remove the specimen from the mould easier the moulds were greased before casting. After taking the cubes out of the moulds they were cured in curing tank for 7 and 28 days for the respective compressive strength tests.

Cylinder moulds of 100mm diameter and 200mm height were used to cast cylinder specimens. In order to remove the specimen from the mould easier the moulds were greased before casting. After taking the cylinders out of the moulds they were cured in curing tank for 7 and 28 days for the respective split tensile strength tests.

Prism moulds of 500x100x100mm were used to cast prism specimens. In order to remove the specimen from the mould easier the moulds were greased before casting. After taking the prisms out of the moulds they were cured in curing tank for 7 and 28 days for the respective flexural strength tests.

IV. RESULTS AND DISCUSSIONS

Fresh Concrete Test Results

From the fresh concrete test results shown in the table 4, we can observe that the slump flow diameters of all the mix compositions are in the range of 700-592 mm, the $T_{50\ cm}$ slump flow times are in the range of 3-7.7 seconds, the J-Ring test values are in the range of 6-13.1 mm, the V-funnel flow times are in the range of 8-18.4 seconds, the V-funnel $T_{5\ minutes}$ flow times are in the range of 1.8-5.8 seconds and the U-Box test values are in the range of 8-58 mm. Hence all the mixtures are not considered as Self Compacting Concrete except A_0V_0, A_1V_1, A_1V_2, A_2V_1, A_2V_2, A_3V_1 because those mixtures did not satisfy the acceptance criteria of Self Compacting Concrete. Also from the results it is found that control mix (A_0V_0) shows good filling ability, passing ability and segregation resistance compared to all other mixtures, this indicates that incorporation of glass fibres affect the filling ability, passing ability and segregation resistance of Self Compacting Concrete. In all the mixtures other than control mix, mix A_1V_1 shows good filling ability, passing ability and segregation resistance, this indicates that as the aspect ratio and percentage of volume fraction of glass fibres increases the filling ability, passing ability and segregation resistance of Self Compacting Concrete decreases.

Table 4 Fresh Concrete Test Results

Mix ID	Slump flow (mm)	T_{50cm} Slump flow (sec)	J-Ring (mm)	V-funnel (sec)	V-funnel $T_{5minutes}$ (sec)	U-Box (mm)
A_0V_0	700	3	6	8	1.8	8
A_1V_1	684	3.5	7.4	9.2	2.1	12
A_1V_2	658	4.2	8.1	11.3	2.5	22
A_1V_3	632	4.9	9.6	13.1	3.2	31
A_1V_4	612	5.4	11.4	17	4.4	38
A_2V_1	672	3.9	7.8	9.6	2.4	18
A_2V_2	654	4.6	8.3	11.8	3	24
A_2V_3	626	5.5	10.1	14.2	3.8	36
A_2V_4	603	6.2	12.2	17.8	4.9	45
A_3V_1	661	4.2	8.6	10.4	2.7	23
A_3V_2	642	5.1	10	12.2	3.5	34
A_3V_3	617	6.3	11.6	15.1	4.5	47
A_3V_4	592	7.7	13.1	18.4	5.8	58

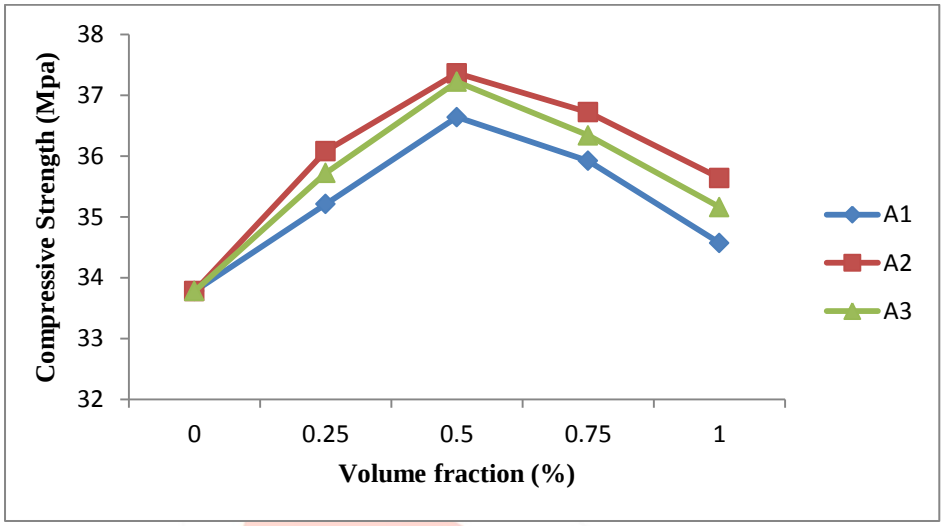
Hardened Concrete Test Results

From the hardened concrete test results shown in the table 5, we can observe that the Compressive strength of all the mix compositions are in the range of 33.78-37.36 Mpa for 7 days and 48.37-53.34 Mpa for 28 days, the Split Tensile strength are in the range of 4.12-4.84 Mpa for 7 days and 4.52-5.38 Mpa for 28 days and the Flexural strength are in the range of 5.92-6.86 Mpa for 7 days and 6.52-7.67 Mpa for 28 days. Also it is found that all the mix compositions attains maximum strength compared to control mix (A_0V_0), this indicates that the incorporation of glass fibres improves the strength. Compare to all mixtures, mix A_2V_2 attains greater Compressive strength and Flexural strength, this indicates that the Compressive strength and Flexural strength of Self Compacting Concrete increases up to aspect ratio 1285 and percentage of volume fraction 0.5 of glass fibres. Also compare to all mixtures, mix A_2V_3 attains greater Split Tensile strength, this indicates that the Split Tensile strength of Self Compacting Concrete increases up to aspect ratio 1285 and percentage of volume fraction 0.75 of glass fibres.

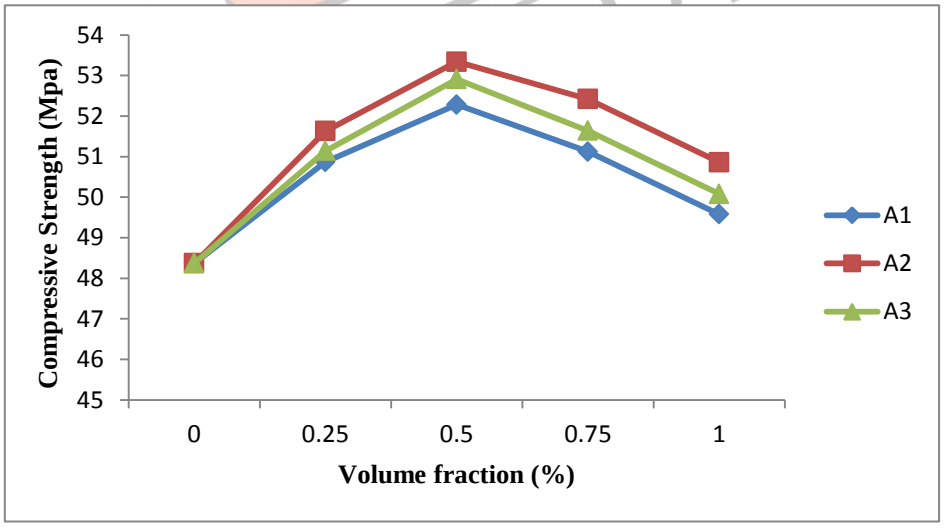
Table 5 Hardened Concrete Test Results

Mix ID	Compressive Strength (Mpa)		Split Tensile Strength (Mpa)		Flexural Strength (Mpa)	
	7 days	7 days	7 days	28 days	28 days	28 days
A_0V_0	33.78	4.12	5.92	6.52	4.52	48.37
A_1V_1	35.21	4.36	6.48	7.21	4.82	50.87
A_1V_2	36.64	4.52	6.63	7.35	5.05	52.28
A_1V_3	35.92	4.74	6.54	7.28	5.21	51.12
A_1V_4	34.57	4.63	6.42	7.24	5.12	49.58
A_2V_1	36.08	4.45	6.52	7.43	4.95	51.63

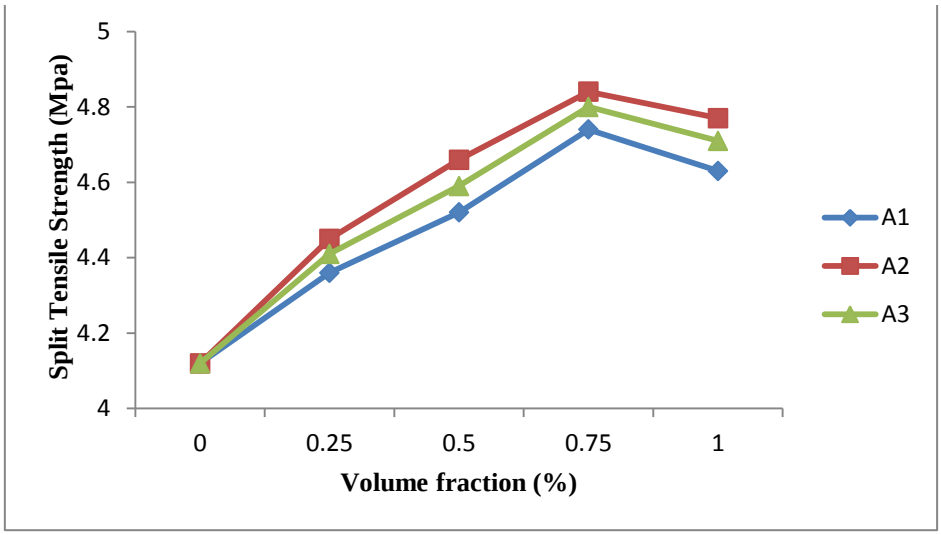
A_2V_2	37.36	4.66	6.86	7.67	5.16	53.34
A_2V_3	36.72	4.84	6.68	7.58	5.38	52.42
A_2V_4	35.64	4.77	6.49	7.49	5.28	50.86
A_3V_1	35.72	4.41	6.5	7.35	4.89	51.14
A_3V_2	37.22	4.59	6.71	7.52	5.11	52.91
A_3V_3	36.34	4.80	6.59	7.46	5.30	51.64
A_3V_4	35.16	4.71	6.48	7.38	5.22	50.08



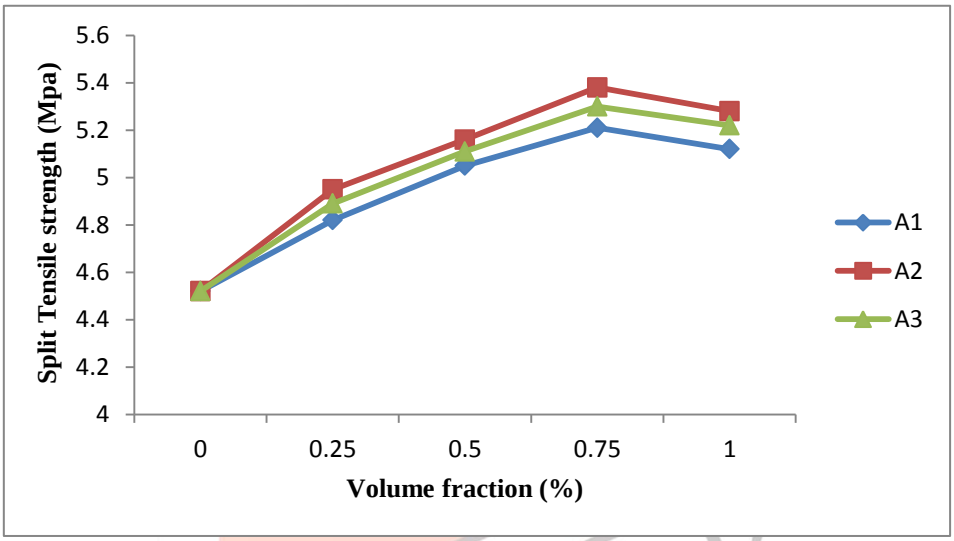
Graph 1 Compressive Strength 7-days



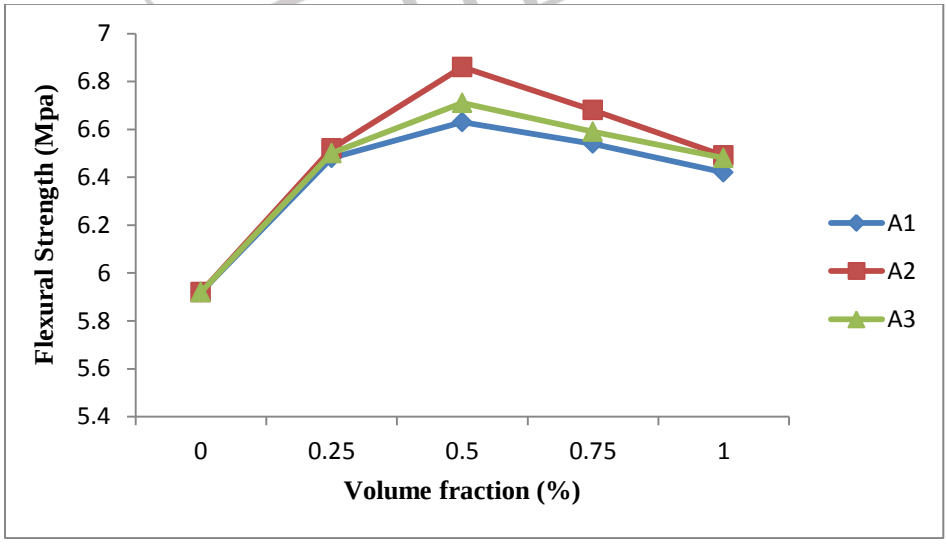
Graph 2 Compressive Strength 28-days



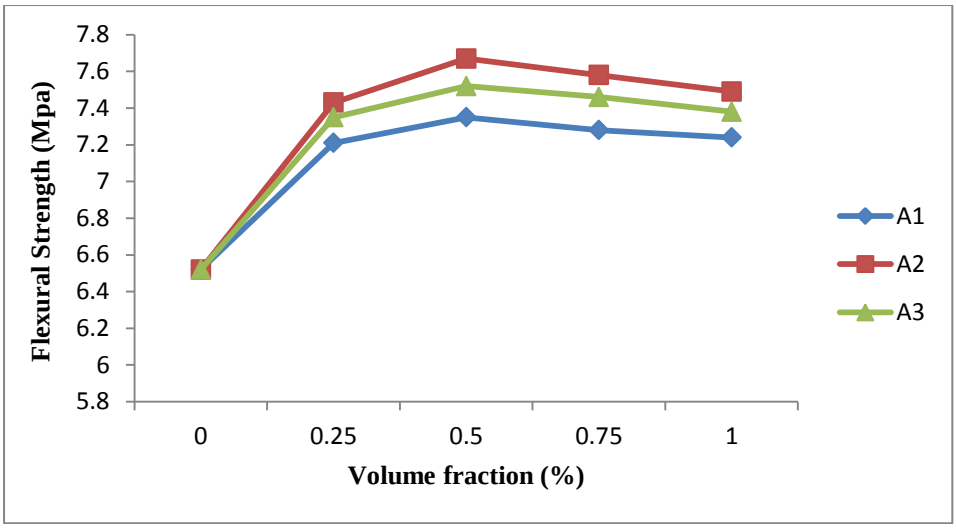
Graph 3 Split Tensile Strength 7-days



Graph 4 Split Tensile Strength 28-days



Graph 5 Flexural Strength 7-days



Graph 6 Flexural Strength 28-days

V. CONCLUSIONS

The Self Compacting Concrete of M40 grade has satisfied all the important characteristics of filling ability, passing ability and segregation resistance. As the aspect ratio and volume fraction of glass fibre increases the flowability and passing ability of Self Compacting Concrete decreases. The brittleness of concrete is improved by addition glass fibre. Since concrete is very weak in tension, the glass fibres are beneficial in axial-tension to increase tensile strength. SCC gives good finishing as compared to ordinary concrete without any external mean of compaction. The addition of 0.5% of glass fibres attains maximum compressive strength and flexural strength compared to 0.25%, 0.75% & 1% of glass fibres. The addition of 0.75% of glass fibres attains maximum split tensile strength compared to 0.25%, 0.5% & 1% of glass fibres. The addition of glass fibres of aspect ratio 1285 attains maximum flexural strength, split tensile strength and compressive strength compared to 875 and1714. The optimum volume fraction and aspect ratio of fibre for better performance in terms of Compressive strength and flexural strength was found to be 0.5% and 1285 respectively. The optimum volume fraction and aspect ratio of fibre for better performance in terms of Split tensile strength was found to be 0.75% and 1285 respectively. Development of multiple cracks and micro cracks are prevented with the use of glass fibres.

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