

Experimental Investigation on Mechanical Properties of AR Glass Fibre Reinforced Self Compacting Concrete

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Abstract

The plain cement concrete has brittle in nature and low tensile strength. Self-Compacting Concrete (SCC) is an efficient choice in construction because of its inherent capacity to fill gaps and flow without the need for external vibration. The necessity of self-compacting concrete can be recognized by seeing the growing issue of a trained labour shortage in the building sector. The advantage of SCC is that it allows for an earlier development of concrete strength and shortens the construction period. The flexure and flow properties of self-compacting concrete reinforced with AR Glass fibre are examined in the current paper. Concrete was combined with four various percentages of AR Glass Fibre (0.25percent, 0.5percent, 0.75percent and 1percent). To understand the mechanical attributes of different specimens of self-compacting concrete made from different types of fibre, at 7 and 28 days, compressive strength, split tensile strength, and flexure strength are assessed. Slump flow, L-Box, U-Box, T50cm tests also acted upon the analyze the flow of self-compacting concrete. As the amount of fibre increases, more super plasticizer was needed. Based on the calculation of maximum strengths for ARGFSCC will give the best strengths and the optimal fibre mix will be in the range of 1% by volume.

Keywords: Self compacting concrete, hardened concrete, flow, AR glass fibre, strength properties.

INTRODUCTION

ANFIS was used during the analytical model to simulate SCC's compressive strength. The dataset from 55 historical study was used. 18 distinct combinations of the mixture design proportion elements were analyzed in order to investigate the potential SCC property [1].

The construction materials utilised in the construction firm most usually is cement concrete. Compaction process is necessary before casting conventional utilising concrete to just provide adequate strength and durability. Concrete that has been improperly designed and compacted will develop voids, producing subpar concrete. The advent of SCC has fundamentally altered how concrete is made without

compaction [2]. Even in the crowded reinforced area of the structure, the development of SCC has resulted in higher concrete quality and more effective construction procedure.

Pozzolans are the best substitute powder for cement because they offer sufficient strength, improved durability, lower cost, less energy use, and lower greenhouse gas emissions [3]. Mechanical properties of glass fibre composites [4] have clarified exploratory examination on. The test outcomes have demonstrated that the expansion of Coal debris expands the general mechanical properties of the composite material when contrasted with the polymer composite materials. 20 present polymer composite material is better consequence of elasticity in concrete properties.

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The SCC mix can be made fluid and cohesive by adding a lot of fine powder components and Superplasticizer (SP) [5]. The material was simulated using ANN. number in SCC. The trained network might be used to specify the mix proportioning of SCC mixtures With an R2 value ranging from 0.63 to 1.0, As a result, the trained network may be used for network prediction. [6]. An emerging field called fibre-reinforced SCC combines the benefits of SCC with the advantages of fibre. The use of fibre lessens the brittleness of concrete, which is weak in tension. It has undergone extensive effort to integrate several types of fibres to make it tough, long-lasting, and affordable. Artificial fibres used in the building sector include steel, glass, polypropylene, and carbon fibres. Natural fibres are easily available and inexpensive, while artificial fibres are more expensive. There was no shortage of natural fibres, including kapok, wood, sugarcane, coconut, pineapple, and sugarcane. Brown and white coconut fibres, both adult and immature. White fibres don't possess the same physical and mechanical properties as brown fibres. 2,500 tonnes of coir fibre have been produced overall. 36 percent of the brown fibre and 60 percent of the white fibre are produced in Sri Lanka and Tamil Nadu, respectively. 90 percent of the coir consumed worldwide is produced in India and Sri Lanka combined. Coir fibre helps prevent degradation by having strong resistance to fungus, rot, and moths. It had no impact when exposed to moisture and humidity. It may have an elastic character, which enables it to maintain its initial position even under repeated stress. It also provides good protection from both sound and temperature. Coir fibre is also used in concrete is encouraged by these advantages [7].

The use of cement mass in place of concrete that contained 15% silica fume, 2% coconut fibre, and 1% SP meant that the concrete's mechanical characteristics had improved [8]. [9] examined the MK and rice husk-containing SCC's resilience to chemicals and chloride. They discovered that MK's greater silica content enhances the pozzolanic reaction of concrete, increasing its strength and durability. Researchers are going toward the world of because natural resources are being degraded and the rise in agricultural waste, innovation is required. An important factor is selecting the appropriate substance at the appropriate time. If available locally, Agro waste might utilised in the industry of construction. Concrete is a flexible substance used in building. Depending on the use they were to serve in the construction industry, numerous concrete types were employed. SCC is employed in areas with crowded reinforcing and challenging vibration processes.

Streamlining of the joined utilization of two distinct kinds of fibre in cementations networks [10] has examined. The two sorts of strands that have been utilized are a fibrillated polyethylene mash and high modulus polyethylene fibre. The impacts of various fibre volume portions of the two filaments and their collaboration on the effect opposition, flexural quality and durability and compressive quality of cementitious materials produced with an elite blender have been researched. The impact of silica rage on the usefulness and the compressive quality of superior cements [11] has contemplated. The usefulness and the compressive quality of silica smoulder cements have been examined at minimum water-cement materials proportions with a naphthalene sulphate superplasticizer. The impact of various valuable cementations materials on mechanical aspects of superior cement [12] have examined. The compressive strength of cement containing GP concrete, fly debris and silica smoulder is greater (46%) contrasted with the compressive quality of cement containing just GP concrete at 28 years old days.

The coconut fibre is the strongest natural fibre available because it can withstand strain 4-6 times more than any various natural fibres [13]. The workability of mixtures enhanced with coconut fibre has deteriorated because of the volume of coconut fibre to absorb water [14].

Reinforcing of solid utilizing Glass fibre [15] has drawn out the consequence of a trial concentrate on. The trial examination in the glass filaments in various rate zero to 0.1% has been carried out and finding the mechanical properties.

Glass fibre fortified cement and its properties [16] have directed the test concentrate on the. It has been reasoned that Flexural quality and split rigidity show increment of right around 15 to 20% when contrasted with 0% glass filaments.

MATERIAL DETAILS

Cement

53 Grade Ordinary Portland cement that conformed to IS: 12269 was the type of cement employed in the experiment. For general construction projects, ordinary Portland cement is employed. Calcareous materials, like chalk or limestone, and argillaceous materials, like shale or clay, are needed as raw ingredients to make Portland cement grinding the raw materials, mixing them thoroughly in specific ratios based on their structure and clarity, and then putting them through a kiln fire at a certain temperature of about 13000C to 15000C are the steps required to make cement. The clinker is ground when it has cooled into a fine powder and around 2 to 3 percent of gypsum is added. A "Portland cement" is the end result of the process. The supplied cement sample has 6% fineness. The offered sample of cement has a normal consistency of 30%. The offered sample's initial setting time is 35 minutes. The sample's final setup time is 8 hours. The provided cement sample has a specific gravity of 2.76.

Fine Aggregate

All everyday concreting sands are appropriate for GRC. Both over whelmed or rounded sands can be used. River sand turned into used as exceptional mixture. Specific gravity of sand is 2.47. Fineness modulus of sand is calculated as 2.97. The cumulative weight for the sieve analysis is 0.086 in kg and cumulative percentage retained obtained from 8.6 as shown in Table 1.

Table 1. Cumulative Percentage

Sl. No.	IS sieve size (mm)	Weight retained (g)			Cumulative weight (kg)	Cumulative % retained	% of Fineness
		Empty weight of sieve (kg)	Retained weight of sieve (kg)	Weight of retained soil (kgm)			
1	4.75	0.400	0.486	0.086	0.086	8.6	91.4
2	2.36	0.378	0.488	0.108	0.194	19.4	80.6
3	1.18	0.346	0.658	0.310	0.504	50.4	49.6
4	0.600	0.322	0.448	0.126	0.630	63	37
5	0.425	0.326	0.542	0.206	0.836	83.6	16.4
6	0.300	0.342	0.444	0.102	0.938	93.8	6.2
7	0.150	0.328	0.390	0.056	0.994	99.4	0.6
8	0.075	0.282	0.288	0.006	1	100	0
9	Pan	0.270	0.270	0.000	1	100	0

COARSE AGGREGATE

The local crusher plant with a range of sizes provided the coarse aggregate. The 20mm retained aggregates were piled separately for usage after being sieved. In this experiment, 20mm well-graded aggregate in accordance with IS: 383-1970 was used. The coarse aggregate has a specific gravity of 2.65. The coarse aggregate's unit weight is 2.82.

Water

The least expensive but most crucial component of concrete is this. Water must be thoroughly analysed in terms of both quantity and quality. The qualities of the other elements are frequently under strict supervision in practise, while the water's purity is frequently disregarded. We must examine the purity and quality of water because the latter affects the former's power. The water that is used to create the solution must be pure and free of dangerous contaminants, such as oil, alkali, acid, etc. Generally speaking, laboratories should make solutions using distilled water. In general, concrete can be successfully made with water that has less total dissolved solids than 2000 milligrams per litre. Even though larger concentrations aren't necessarily bad, they can have negative effects on some cement and should be avoided if possible. A good general rule to remember is that water should be pure enough to drink before it can be used to mix concrete.

AR Glass Fibre

Concrete-specific Alkali Resistant (AR) Glass Fibres chopped strand is available. They are made from a carefully designed glass composition that contains the ideal amount of zirconia (ZrO₂) to be used in concrete. For Premix GFRC and other applications involving mortar and concrete reinforcement, AR Glass Fibres are especially well suited. They are simple to include into concrete mixtures, have excellent tensile strength and modulus, and do not rust like steel. All of our alkali resistant glass fibre materials are created in accordance with PCI and GRCA requirements. The schematic diagram as shown in Figure.1, ASTM C1666/C1666M, and EN 15422. The outcome of the AR Glass fibre properties are shown in Table.2.



Figure 1. AR Glass Fibre

Table 2. Properties of AR glass fibre

Length	6 mm
Density	2.70g/cm ³
Tensile Strength	2480MPa
Elastic Modulus	80GPa
Breaking Elongation	3.6%

ADMIXTURES

In order to enhance qualities like workability, curing temperature diversity, setting time, or colour, concrete may be mixed with different materials in addition to cement, aggregate, and water. There are more modern admixtures that offer an increasing range of opportunities for efficiency acceleration.

Superplasticizers (high variety water reducers) are applied to concrete to increase workability and decrease water content. The superplasticizers particularly Sulphonated naphthalene-formaldehyde condensates (SNF) become utilized in our observe. From the marsh cone check most excellent dosage of superplasticizers to combine turned into located out. The properties of superplasticizer as shown in Table.3

Table 3. Properties of super plasticizers

Appearance	Brown liquid
Specific Gravity	Typically, 1.19 at 25Oc
Chloride Content	Nil to BS 5075
Air Entrapment	At standard dosages, less than 2% more air is typically entrained.
Alkali Content	Frequently less than 72.0g Na ₂ O equivalent per litre of admixture. There is a fact sheet available on this.

Viscosity Modifying Agent

In this investigation, VMA Master matrix 2 (Glenium Stream 2) with a specific gravity of 1.19 was employed.

Test on Fresh Concrete

The two methods listed below are used in laboratories to determine if concrete is workable.

1. Slump Cone Test
2. Floating Table Test

SLUMP CONE TEST

The most common and widely performed test to evaluate if freshly laid concrete is workable is the slump test. On construction sites, the low-cost consistency testing is used to quickly finding if a batch of concrete is acceptable or not. The tool is a cone-shaped mould with dimensions of 300 mm in height, 100 mm at the top, and 200 mm at the bottom. In Figure 2, the assembly is displayed. In this test, three equal layers of concrete are poured into the mould. Using a tamping rod, 25 strokes are used to compact each layer. By raising the slump cone vertically during moulding, the elevation change of the concrete is measured. Slump value, from the experiment, is found as 90 mm



Figure 2. Slump cone test

Flow Table Test

Information on filling capability (flowability) and passing competency is provided by this test. As shown in Figure 3, the device is composed of a standard Abram's cone and a Slump flow board is a non-absorbent rigid plate that is at least one metre square and coated with plywood, plastic, metal, or another similar material. The slump flow test analyzes concrete's horizontally spread cone specimens, largely matches the slump test in all other respects. The slump flow board's centre is where the Abram's cone is situated upside-down or with the enormous opening pointing downward (small opening down). Once it has been filled in one lift, the cone is then raised to a height of 230mm to allow the slump flow board with fluid concrete (without rodding or additional consolidation). By averaging the diameters that were largest and perpendicular to this direction, the diameter of the final concrete "patty" was determined. The two diameters' notable variances suggest that the surface has to be levelled. By experiment, it is found out as 14 per cent.



Figure 3. Flow test

EXPERIMENTAL PROGRAM FOR HARDENED CONCRETE

Compressive Strength on ARGFSCC With M₅₀ Grade

The compression testing machine was used to test the cube by inserting flat pads on the top and bottom. Figure 4 and Table 4 show the comparison of cube compressive strength of ARGFSCC. The standard concrete without any mix of fibres has the maximum compressive strength of 54.28MPa. With 0.25%, 0.50%, 0.75% and 1% of ARGF in M₅₀ grade concrete, the compressive strength is 68.56, 65.22, 61.02 and 58.86 MPa respectively. In comparison with conventional concrete, ARGF addition of 1%, improved the compressive strength by 26.30%. The addition of ARGF beyond 1% does not improve the compressive strength.



Figure 4. Cracking of ARGFSCC Specimen in Axial Compression

Table 4. Compressive Strength on ARGFSCC

Sample No	%Fibre Volume	Compressive Strength (MPa) 7 days	Average Compressive Strength (MPa) 7 days	Compressive Strength (MPa) 28 days	Average Compressive Strength (MPa) 28 days
1	Conventional Concrete	38.78	38.24	55.34	54.28
2		37.64		53.68	
3		38.30		53.82	
1	0.25 % ARGFSCC	51.58	51.22	67.60	68.56
2		51.34		68.40	
3		50.74		69.68	
1	0.50 % ARGFSCC	48.60	47.46	64.12	65.22
2		45.94		66.38	
3		47.84		65.16	
1	0.75% ARGFSCC	43.88	43.21	59.68	61.02
2		43.42		62.54	
3		42.34		60.86	
1	1 % ARGFSCC	41.16	41.16	57.76	58.86
2		40.38		59.88	
3		41.96		58.94	

Split Tensile Strength on Argfscc with M₅₀grade

The cylinder was put in a universal testing machine with the force applied perpendicular to the cylinder's axis, and the load at which the cylinder split was recorded. The tensile strength was then determined, and the results are displayed in Table 5.

Figure 5 and Table 5 show the detail of 28 days split tensile strength. The conventional concrete without any mix of fibres has the higher split tensile strength of 5.96 MPa. The 0.25%, 0.5%, 0.75% and 1% of ARGFSCC in M₅₀ grade concrete, the split tensile strength are 6.90, 6.12, 5.40 and 4.80 MPa respectively. In comparison with conventional concrete, ARGF addition of 1%, improved the split tensile. Addition of ARGFSCC beyond 1% does not improve the split tensile strength any further.



Figure 5. Cracking of ARGFSCC Specimen in Indirect Tension

Table 5. Split Tensile Strength on ARGFSCC

Sample No	% Fibre Volume	Split Tensile Strength (MPa) 7 days	Average Split Tensile Strength (MPa) 7 days	Split Tensile Strength (MPa) 28 days	Average Split Tensile Strength (MPa) 28 days
1	Conventional Concrete	4.18	4.20	5.91	5.96
2		4.28		5.85	
3		4.14		6.12	
1	0.25 % ARGFSCC	5.14	5.20	6.65	6.90
2		5.28		7.20	
3		5.20		6.85	
1	0.50 % ARGFSCC	4.75	4.80	5.90	6.12
2		4.40		6.16	
3		5.25		6.30	
1	0.75% ARGFSCC	4.35	4.20	4.90	5.40
2		4.42		5.45	
3		3.84		5.85	
1	1 % ARGFSCC	4.10	3.86	5.10	4.80
2		3.80		4.85	
3		3.68		4.45	

Flexural Tensile Strength on ArgfscC with M₅₀ Grade

By applying an equal concentrated stress at one third of the beam, the flexural strength was achieved. The beam was merely held in place. The results of the testing in UTM, including the ultimate load and rupture moduli values, are presented in Table 6. Figure 6 and Table 6 show details of the 28 days flexural strength. The conventional concrete without any mix of fibres has the maximum flexural strength of 9.18 MPa. With 0.25%, 0.50%, 0.75% and 1% of ARGF in M₅₀ grade concrete, the split tensile strength is 11.22, 10.92, 10.60 and 10.42 MPa respectively. In comparison with conventional concrete, ARGF addition of 1%, improved the flexural strength. Addition beyond 1% of ARGF does not improve the flexural strength any further.



Figure 6. After Failure of Flexure Strength of Prisms on ARGFSCC

Table 6. Flexural Strength on ARGFSCC

Sample No	% Fibre Volume	Flexural Strength (MPa) 7 days	Average Flexural Strength (MPa) 7 days	Flexural Strength (MPa) 28 days	Average Flexural Strength (MPa) 28 days
1	Conventional Concrete	7.35	7.24	9.16	9.18
2		7.22		9.30	
3		7.15		9.10	
1	0.25 % ARGFSCC	9.20	9.24	11.32	11.22
2		9.18		11.15	
3		9.35		11.20	
1	0.50 % ARGFSCC	8.45	8.46	11.10	10.92
2		8.24		10.80	
3		8.70		10.88	
1	0.75% ARGFSCC	8.40	8.18	10.40	10.60
2		7.90		10.85	
3		8.25		10.55	
1	1 % ARGFSCC	8.26	8.10	10.25	10.42
2		7.86		10.35	
3		8.20		10.65	

MATERIAL TEST FOR SCC

Need For Scc

Fibres added to concrete boost its tensile strength, and the use of AR Glass in concrete can solve the issue of self-compacting concrete forming microcracks as it cures. Concrete is made stronger by AR Glass fibres, while the matrix safeguards the fibres. In a cementations composite, the fibres' main function is to control cracks and boost tensile strength and toughness. The fibres also help the composite's deformation properties. Due to its high elastic modulus, AR Glass fibres boost flexural strength while reducing water permeability. When the fibres are extracted during the post-cracking stage, energy is absorbed, and cracking is decreased.

Mix Design Procedure and Fibre Dosage

As there is no suitable design approach for SCM, the final composite samples were developed using the trial-and-error method, which involved experimenting with different ratios of fly ash and superplasticizer to find the mix that has the right workability and meets the self-compacting criteria. The length of fibre is 1.2mm were added to the self-compacting mix with different percentages (0.25%, 0.5%, 0.75% and 1%). All the mix proportion value given in Table.7

Table 7. Mix Proportion for SCC with ARGF

Sl. No	Designation	Mix Proportion
1.	SCC1	0.25% ARGF
2.	SCC2	0.5% ARGF
3.	SCC3	0.75% ARGF

4.	SCC4	1% ARGF
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SLUMP FLOW TEST (T-500)

The amount of time T500 needed for the concrete to spread to a 500 mm diameter is also evaluated in order to gauge flow ability. With increasing slump flow value, the slump flow becomes more capable of filling formwork while bearing its own weight. According to EFNARC regulations, SCC ought to be at least 650mm. Although 50mm, as with the accompanying flow table test, might be adequate, there is no widely accepted consensus regarding realistic tolerances around a given Figure. The T500 time functions as an additional flow indication. A shorter duration indicates greater flow ability, and vice versa. In situations of extreme segregation, the majority of the concrete pool's centre will continue to contain coarse aggregate, and the outer edges will continue to include mortar and cement matrix. A mortar boarder clear of coarse aggregate may appear along the edge of the concrete pool in the case of mild segregation. Since segregation is a phenomenon of time that might occur over a longer period of time, the lack of any of these occurrences does not preclude the possibility that it will. The flow diagram as shown in Figure. 7



Figure 7. Slump flow test

V- Funnel Test

Using the specified V-funnel test, the maximum amount of concrete that can be filled aggregate size of 20mm is determined. The funnel has been filled with concrete, and the time it takes the device to process it is examined. The funnel can then be filled again after that concrete and given five minutes to settle. The flow time will dramatically lengthen if the concrete exhibits segregation. Shorter flow periods indicate more flow ability; this test gauges the concrete's ease of flow. EFNARC advises that a flow time of 10 seconds is sufficient for SCC. The flow is restricted by the inverted cone shape, and extended flow periods may indicate that the mixture is prone to blockage. Concrete segregation will exhibit a less steady flow and an increase in flow time after five minutes of setting. The flow diagram as shown in Figure. 8.



Figure 8. V -Funnel Test

L – Box Test

The test measures the concrete's ability to flow and how vulnerable it is to obstruction by reinforcing. An L-shaped rectangular box with vertical and horizontal portions is what makes up the device. The vertical and horizontal sections are separated by a movable gate that is reinforced with vertical lengths of bar. After the structure's vertical part has been The gate is raised as concrete is being poured, allowing it to flow into the horizontal portion. The concrete height at the end of the horizontal portion is given as a percentage of the height still present in the vertical segment once the flow has stopped. When the concrete is at rest, the slope is obvious. It shows how easily concrete can pass through the bars, or how much movement is constrained. Standard reinforcing considerations dictate that the bar section's aggregate size should be three times the maximum. which can have varying diameters and spacing. In general, the bars can be placed at any spacing to subject the concrete to a more or less rigorous test of its ability to pass. Visual inspection can reveal any obvious obstruction of coarse aggregate beneath the reinforcing bars. The flow diagram as shown in Figure. 9.



Figure 9. L – Box Test

We draw the conclusion that the addition of AR-Glass fibres has no impact on the SCC's filling, passing, or segregation resistance based on the test results that were obtained. By changing the amount of AR. Four different ARGFSCC trial combinations with glass fibres are put through a workability test. The result comes within the range of suggested values when the amount of AR Glass fibre added is at its highest, proving that the amount added directly affects the flow ability of ARGFSCC. The SCC4 values, which represent 1% of AR Glass fibre, are clearly well within the EFNARC-approved tolerance parameters. The above all SCC test results are sown in table.8

Table 8. Shows the Test Results for SCC

Sl. No	Designation	Slump Flow(mm)	T500(mm)	V-Funnel (Sec)	L- Box(h2/h1)
1.	SCC	710	2	9	0.82
2.	SCC1	690	2.5	8	0.9
3.	SCC2	670	3.2	8.5	0.95
4.	SCC3	650	4.1	9	1.1
5.	SCC4	640	6	11	1.3

CONCLUSIONS

The following observations and comments were achieved upon doing analytical and experimental investigation on ARGFSCC:

The ARGFSCC concrete is utilized for economical and durable substantial constructions. ARGFSCC

are broadly utilized as a fiber built up substantial everywhere. Parcel of examination work had been done on ARGFSCC and part of specialists work unmistakably over it. In light of the exploratory work, a decrease in draining is seen by expansion of glass strands in to the substantial. A decrease in draining works on a superficial level respectability of cement, improve its homogeneity and lower the likelihood of breaks.

Based on the calculation of maximum strengths for ARGFSCC will give the best strengths and the optimal fibre mix will be in the range of 1% by volume. When compared to conventional and SCC, the findings for the workability of SCC from tests including, slump flow, L-Box, U-Box, T50cm, and fill box showed promising results. The percentage increase in all the hardened concrete of SCSC was 27.28%, 40.49% and 26.32% compared to control mix of 28 days the required basis resulted in increasing the mechanical properties with age of concrete.

Research on the mechanical properties of AR (Alkali Resistant) glass fibre reinforced self-compacting concrete (SCC) could explore several potential future studies like, Optimization of Fibre Content, Durability Studies, Nano Structural Fibres and modelling.

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