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Original Article

Behavior of Conventional Self-Compacting Concrete to a Novel Glass Fiber Reinforced Self-Compacting Concrete Under Tension

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Abstract *- This research investigates and compares the behavior of conventional self-compacting concrete (SCC) with a novel glass fiber reinforced self-compacting concrete under tension. Self-compacting concrete is known for its ability to flow and fill formwork without needing external vibration. Adding glass fiber reinforcement to self-compacting concrete offers potential improvements in tensile strength and cracking resistance. To compare self-compacting concrete's split tensile strength behavior with novel glass fiber reinforced self-compacting concrete. In this experimental study, a total of 36 samples are used, 18 samples for self-compacting concrete and the remaining 18 samples for glass fiber reinforced self-compacting concrete. The self-compacting concrete contains 43-grade ordinary Portland cement, fine aggregate, coarse aggregate (20mm), water cement ratio of 0.45, and 0.6% superplasticizer added according to the weight of cementitious material. For the glass fiber-reinforced self-compacting concrete, 3% glass fibers were added according to the weight of the cementitious material in self-compacting concrete. The split tensile strength of the concrete was tested. The split tensile strength of glass fiber reinforced self-compacting concrete is increased by 5% compared to self-compacting concrete. The SPSS, version 26 software, did the statistical analysis results. The experimental study shows that M20 grade glass fiber reinforced self-compacting concrete gives greater split tensile strength than conventional M20 grade self-compacting concrete.*

Keywords *- Split tensile strength, Strength behavior, Novel glass fiber reinforced self-compacting concrete, Ordinary portland cement, Glass fiber, Self-compacting concrete.*

1. Introduction

Concrete is a highly used material in the construction industry, materials used to make concrete are cement, fine aggregate, coarse aggregate, water and admixtures. When the concrete containing a slum of 160mm is called self-compacting concrete, it is also called Self-consolidating concrete (De Schutter et al. 2008). Self-compacting concrete added with glass fiber is called glass fiber reinforced self-compacting concrete. Here we compare self-compacting concrete's split tensile strength behavior with glass fiber reinforced self-compacting concrete. Self-compacting concrete is a mixture of 43-grade OPC cement, fine aggregate (M-sand), coarse aggregate (20mm), water-cement ratio 0.45, and 0.6% superplasticizer added according to the weight of cementitious material(Wong et al. 2012).

Glass fiber reinforced self-compacting concrete contains 43 grade OPC cement, fine aggregate, coarse aggregate (20mm), water-cement ratio 0.45, 0.6% superplasticizer and 3%glass fiber added according to the weight of cementitious material. Superplasticizers will reduce the water-cement ratio, help increase the concrete flow rate and reduce aggregate segregation in concrete. Benefits of self-compacting concrete, which improves the quality of concrete and reduces outside repairs, faster construction times, lower overall costs, facilitation of introduction of automation into construction, self-compacting concrete improved durability and reliability of concrete structures(Kostrzanowska-Siedlarz et al. 2022).

Our team has extensive knowledge and research experience that has translated into high-quality publications (Prabakaran et al., 2022; Matheswaran et al. 2022; Sakthivadivel et al. 2022; Ramesh et al. 2022; Sundar et al., n.d.; Vellaiyan et.al 2022; Tharanikumar et al. 2022; Vivekanandan et al. 2022)

Much research has been done during the last five years on glass fiber reinforced concrete. The total number of articles on this topic over the past five years in google scholar is nearly sixty, and more than twenty in science direct are published. Properties of glass fiber reinforced self-compacting concrete (Wong 2012). The mechanical properties of glass fiber reinforced self-compacting concrete (Rahman 2012). Fiber-reinforced cementitious material (Mindess et al. 1991) Experimental quantification of punching shear capacity for large-scale GFRP-reinforced flat slabs made of synthetic fiber-reinforced self-compacting concrete (AlHamaydeh et al. 2021). Fiber Reinforced Concrete with superplasticizer with less amount of fiber is carried out in the above research works. In this research, 3% of glass fibers were added, and M sand as fine aggregate was used. Also, the split tensile strength behavior of conventional self-compacting concrete and glass fiber reinforced self-compacting concrete was compared. The research does not analyze the M20 grade self-compacting concrete combination with 0.6% superplasticizer and 3% glass fiber reinforced self-compacting concrete. Hence, that combination is taken as the research gap. This combination of the concrete can change the strength of values, and the experiments were carried out for the same. The split tensile strength behavior has been carried out for a curing period of 28 days with admixtures and steel fiber, and the strength behavior of the concrete has been analyzed.

2. Materials and Methods

This study was done in the concrete lab, department of Civil Engineering, Saveetha School of Engineering; two groups of experiments were done. In that one group, self-compacting M20 grade concrete with 0.6% of superplasticizer, aggregates and water added as per the design mix of M20 grade self-compacting concrete and other groups of the concrete specimens were done by the 0.6% of the superplasticizer, 3% of glass fiber, aggregates and water added as a design mix of M20 grade of self-compacting concrete. The calculation is carried out utilizing a G-power of 0.8 with alpha and beta qualities are 0.05 and 0.2 with a confidence interval of 95%. Independent sample T-Test (=.001) value ($p<0.05$) i.e. $p=0.0321$. The quantity of materials is given in table1. Table.2 represents the properties of cement, Table.3 shows the properties of coarse aggregate, and Table.4 shows the properties of fine aggregate.

Table 1. Properties of cement

S.no.	Material	Weight (kg)
1	Cement	0.65
2	Coarse aggregate	2.15
3	Fine aggregate	1.2
4	Fiber	0.0195
5	Water	0.300

Table 2. Properties of cement

S.no	Properties of cement	Results
1	Fineness of cement	90 Microns
2	Standard consistency	30%
3	Specific gravity	3.2
4	Initial setting time	30 min
5	Final setting time	10hrs

Table 3. Properties of coarse aggregate

S.no	Test	Results
1	Sieve analysis	4.41
2	Specific gravity	2.65
3	Size	4.75mm
4	Water absorption	3%

Table 4. Properties of fine aggregate

S.no	Test	Results
1	Sieve analysis	3.22
2	Specific gravity	2.68
3	Size	20mm
4	Water absorption	3.2%

Cement: The standard ordinary portland cement of 43-graded bharathi cement, acquired from a single batch throughout the research, changed into use. Premium quality cement is used. Fine Aggregate (Fine Aggregate is obtained from regionally available, so we use M-Sand), which is passed via A 4.75mm sieve. The fineness modulus of M-sand is (2.6-2.9); Aggregate: Coarse Aggregate is used in projects where the size of coarse aggregate is 20mm (the crushed stones which passed through Is Sieve 80mm, 40mm, and 20mm); water: Normal Tap water is available in the region which is used for concrete mixing the ratio of water cement ratio is 0.45 is used, Super plasticizer: (Adhere mix 700 high-grade superplasticizer), Fibers: glass fibers used as shown in fig 1.

Fig. 1 Glass fiber (20mm length)

Materials are calculated and arranged according to weight batching. Materials used for sample preparation are Ordinary Portland Cement, M-sand used as fine aggregate, 20mm crushed stones used as coarse aggregate, 0.6% Adhere mix 700 high-grade superplasticizer, 3% glass fiber and water. The material was mixed without any segregation after the mixture was transferred to the cylindrical mold of dimension 10cm diameter and 20 cm height. Here 18 samples were prepared for self-compacting concrete and 18 samples for novel glass fiber reinforced self-compacting concrete. A total of 36 samples are placed in a curing tank for 28 days; after 28 days, the cylinders are removed from the curing tank and placed in sunlight till the cylinder gets dry. Then sample weight is noted, and the sample is tested in a split tensile machine, as shown in Fig 2.

Fig. 2 Split tensile testing machine

3. Statistical Analysis

The SPSS, version 26 software, did the statistical analysis results; samples T-Test was done separately to find the analytical difference between the self-compacting concrete and glass fiber reinforced self-compacting concrete group. The study had no dependent variable, whereas the split tensile strength, grade of concrete, water/cement ratio, grade of cement, and days of curing were independent variables. Mean, standard deviation and standard error of mean were also calculated with this tool for split tensile strength.

4. Results

The mean split tensile strength behavior of self-compacting concrete and novel glass fiber reinforced self-compacting concrete is calculated. The mean split tensile strength of self-compacting concrete is 4.99N/mm^{2}and novel glass fiber reinforced self-compacting concrete is 5.39N/mm^2. In an experimental study, the glass fiber reinforced self-compacting concrete has higher tensile strength than self-compacting concrete. The increment in split tensile strength is 5%. The statistical parameters also indicate that the difference between the two groups appears significant, as shown in Table 7 below. It was observed that the standard deviation values for both groups were very less. The standard deviation of self-compacting concrete is 0.414, and the standard deviation of glass fiber reinforced self-compacting concrete is 0.677. The self-compacting concrete contains cement, fine aggregate, coarse aggregate, water and superplasticizer.

Table 5. The split tensile strength of the group-1 samples

S.No	Weight of the cylinder In (Kg)	Collapse load (KN)	Split tensile strength of self-compacting concrete in (N/mm^2)
1	4.032	87	5.541
2	4.013	74	4.713
3	4.199	71	4.522
4	4.189	73	4.65
5	4.098	78	4.968
6	4.00	70	4.458
7	4.12	81	5.159
8	4.099	83	5.286
9	4.003	78	4.968
10	4.02	78	4.968
11	4.02	80	5.09
12	4.11	90	5.732
13	4.099	83	5.286
14	4.098	74	4.713
15	4.00	78	4.968
16	4.12	69	4.394
17	4.10	90	5.732
18	4.01	72	4.585

Table 6. Split tensile strength of the group-2

S.No	Weight of cylinders (Kg)	Collapse load (kN)	Split tensile of fiber reinforced strength of self-compacting concrete in (N/mm^2)
1	4.11	94	5.987
2	4.12	99	6.305
3	4.20	108	6.878
4	4.00	76	4.840
5	4.07	77	4.904
6	4.057	74	4.713
7	4.00	83	5.286
8	4.18	87	5.541
9	4.13	85	5.414
10	4.01	106	6.751
11	4.03	70	4.458
12	4.00	82	5.223
13	4.06	81	5.417
14	4.12	78	4.968
15	4.09	80	5.095
16	4.06	80	5.095
17	4.07	77	4.904
18	3.99	83	5.286

Table 7. The comparison of GFR self-compacting concrete & SCC

Group Statistics					
	Groups	**N**	**Mean**	**Std deviation**	**Std. Error Mean**
SPLIT TENSILE STRENGTH	Glass fiber reinforced Self-compacting concrete	18	5.39	0.677	0.160
	Self-compacting concrete	18	4.99	0.414	0.098

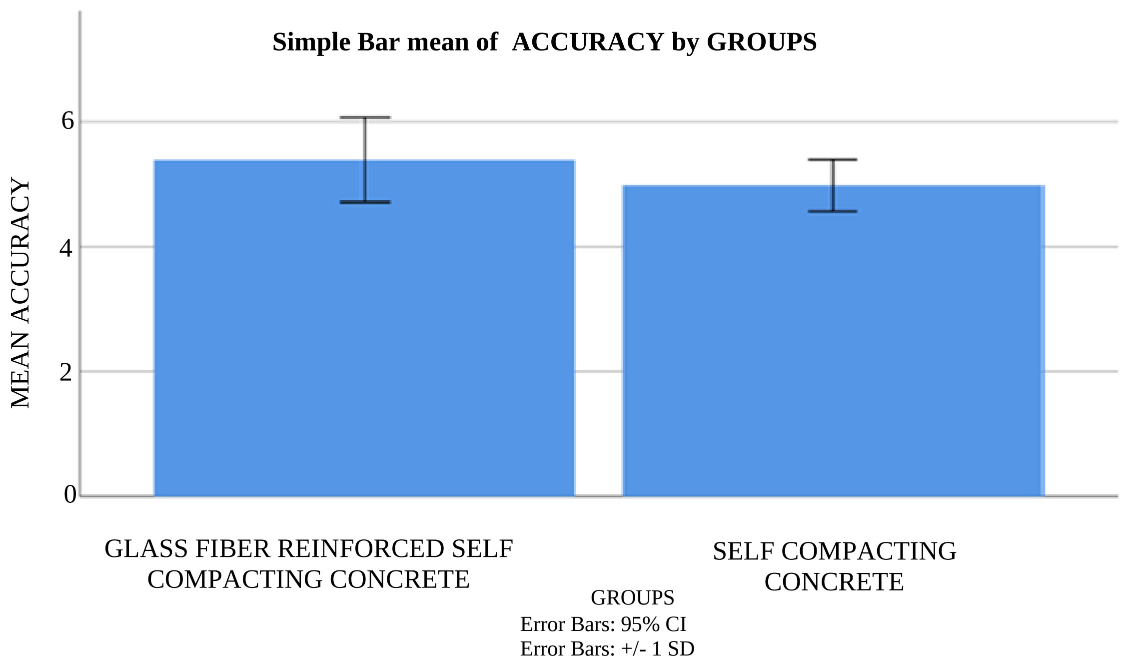

Fig. 3 Bar chart representing the comparison of mean split tensile strength of GFR SCC & SCC

Table 8. The mean, standard deviation, and significance difference

Accuracy	Independent Samples Test								
	Levene's Test for Equality of Variances		T-test for Equality of Means						
	F	Sig	t	df	Sig(2 – tailed)	Mean Difference	Std.Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances are assumed	2.349	0.135	2.179	34	0.036	0.407	0.187	0.027	0.787
Equal variances are not assumed.			2.179	28.149	0.038	0.407	0.187	0.027	0.790

Similarly, the novel glass fiber reinforced self-compacting concrete contains cement, fine aggregate, coarse aggregate, water, superplasticizer and glass fiber. Table 5 represents the split tensile strength values of self-compacting concrete. Table 6 represents the split tensile strength values of a novel glass fiber reinforced self-compacting concrete. Group statistics are given in Table 7.

Independent samples t-test results are presented in Table 8. Fig.1 Shows steel fiber used in concrete. Fig.2 shows a split tensile strength machine. In the statistical analysis, the comparison of mean accuracy values for two groups of glass fiber reinforced self-compacting concrete and conventional self-compacting concrete with a p-value of 0.05 and error bar of 95% with the effective prediction was shown in Fig.3. The error bars with the mean accuracy detection +/- 1 SD.

5. Discussion

The weight of self-compacting is higher than glass fiber reinforced self-compacting concrete. Glass fiber can reduce coarse aggregate in concrete. Hence, glass fiber reinforced self-compacting concrete has less weight compared to self-compacting concrete. Self-compacting concrete is a non-segregating concrete that is placed by means of its own weight (Siddique et al. 2019). The glass fiber reinforced self-compacting concrete also maintains a high flow ratio. There is no segregation in concrete, but glass fiber reinforced self-compacting concrete reduces its aggregate and flow ratio compared to self-compacting concrete (AlHamaydeh et al. 2021).

After finding the split tensile strength of self-compacting concrete and glass fiber reinforced self-compacting, the mean split tensile strength value of self-compacting concrete is 4.99N/mm^{2}., whereas the mean of glass fiber-reinforced self-compacting concrete is 5.39N/mm^{2}. Glass fiber reinforced self-compacting concrete gives higher strength compared to self-compacting concrete (Güneyisi et al. 2019). In glass fiber reinforced self-compacting concrete, we use 3% of glass fiber and 0.6% of superplasticizer (Adhere mix 700 high-grade superplasticizer). Glass fiber acts as a water resistance in concrete. Factors affecting split tensile of concrete are 1. Water cement ratio, 2. Quality of cement, 3. Size of aggregates and fiber, 4. Water penetration, 5. Excess amount of superplasticizer.

There are some limitations for affecting factors: 1) a small size of coarse aggregate is used (10mm-20mm), 2) an optimum amount of fibers should use in glass fiber reinforced self-compacting concrete, 3) higher grade concrete should use where the minimum is M20 grade concrete, 4) limited superplasticizer used (0.6%-1%) (Ahmad, Umar, and Masood 2017). The feature scope is glass fiber reinforced self-compacting concrete used in high-raised buildings, used in bridges and precast sections; we can use glass fiber reinforced self-compacting concrete in beams and columns that can increase lifetime and load-carrying capacity.

6. Conclusion

This paper represents a comparison study between the split tensile strength of glass fiber reinforced self-compacting concrete and conventional self-compacting concrete. Based on the experimental results below, the graph represents that the addition of glass fiber reinforced Self-compacting concrete can show higher split tensile strength compared to self-compacting concrete. The percentage increment in split tensile strength is 5%. It was found promising for the construction of the structure with this type of concrete which may increase load carrying capacity of the structure and can also increase the structure's lifetime; glass fibers reduce the moisture content in concrete.

Authors Contributions

Author NR was involved in data collection, data analysis, and manuscript writing. Author MT was involved in conceptualization, data validation, and critical manuscript review.

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