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Comparative Study on the Behavior of Fiber Reinforced Concrete

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Abstract. Next to water, concrete is the most consumed material in the world. In the construction industries, concrete is a basic material used for high compressive strength, durable, fire resistant but has low tensile strength. This experimental study aimed to investigation the compressive, tensile and flexural strength of the concrete reinforced with three different fibers. Comparative study has been made between metallic: steel fibers and nonmetallic: glass and carbon fiber reinforced concrete. Fibers were used in concrete with fractions of 0%, 0.5%, 1%, 1.5%, 2% and 2.5% by volume of cement in M20 grade of concrete. In this paper, the behavior of cube, cylinder and prism specimen of fiber reinforced concrete (FRC) were deliberated. Addition of fiber in concrete were increased the basic mechanical properties of concrete increases. The steel fiber reinforced concrete attains higher compressive, flexural and tensile strength than concrete with carbon fiber and glass fiber. Carbon fibered concrete attained higher flexural and tensile strength than glass fibered concrete.

Introduction

Fiber reinforced concrete (FRC) has received with the considerable attention recently due to high toughness increases, then the addition of fiber in the concrete was provide the high tensile and flexural strength. In general, fibers used in concretes are steel fiber, glass fibers, carbon fibers [1]. The addition of steel fibres to cement-based composites is predicted to improve their performance [3]. Steel fiber is a key benefits to include good tensile and flexural strength, resistance of spitting, permeability and resistance of impact. It's a good way to boost the mortar's hardness and plastic shrinkage cracking of resistance [2]. Steel fibre of concrete are being concrete are added to improve its mechanical performance and strength of the tensile. Steel fibre are in the bridging cracks that form in concrete. Steel fibres also strengthen the concrete's toughness [4]. Carbon fiber with good work and compaction, tensile and compressive strength of the concrete contain carbon to increase the content. Also he mentioned that a higher carbon content causes lower strength of compressive, believes is due to mix's workability failing to perform properly and resulting in more empty spaces [5]. Carbon fibre increased density of dry and decreased absorption of water, according to findings. Furthermore, the addition to improve the carbon fibre the concrete's tensile strength and compressive strength, as well as its crack resistance [6]. During the hardening stage of concrete, cracks appear. Carbon fibre reinforced concrete was created as a result of new technology for employing carbon fibres to overcome issues material of cement based which associate, which have low tensile strength and fracture toughness is poor of cementations composite [7]. Various studies

on reinforcement of concrete with reasonable quantity addition in the concrete of glass fibres demonstrate improved compression, flexural, and toughness performance; however, the improvement is dependent on type of the glass fibre employed in mixture. Furthermore, glass fibres aid in the preventing the formation of micro-cracks in the concrete contact, resulting in a robust composite with higher crack resistance and ductility [9]. Glass fiber is lesser expensive than the carbon fibre, and the glass fibre offer unique properties such as being undetectable on surface are finished being safe, handle easy to use. When glass fibres are added to the mix, there is no need for change the cement water ratio [8]. The fibres have a channel so the matrix helps to transfer the load between the fibres and protects them from chemical exposure and ambient clamminess by keeping the load-carrying members intact in the required positions and orientation. The influence of fibres in matrix that generates an increase in the matrix's impact strength as well as increases in tension, because concrete is weak in tension. Glass fibres have a high modulus of elasticity and tensile strength [10]. Although prior researchers have researched and separated these concretes, no previous comparisons have been performed using the mix proportions as same, fraction volume of fiber processing the settings, or mechanical testing conditions.

Research Significance

This paper we are going to provide the comparative study on the behavior of compressive, tensile and flexural strength of fiber reinforced concrete and the cost of fiber, that the concrete was containing the various types of the steel fiber, carbon fiber, and glass fiber short fibers. In fiber volume of fraction and length of the fiber then same mixing procedure were subjected. Compare and highlight the superior properties of different fiber reinforced concrete

Material Properties

Cement, Fine aggregate and Coarse aggregate

In this experimental investigation, cement ordinary Portland cement (PPC) (43Grade) used with a 3.18 of specific gravity. 254 min and 48 min was the final and initial setting time of the respective cement. M sand used as a fine aggregate for this study. M sand was confirming as a zone II with 2.45 of specific gravity, 2% of water absorption and 3.18 of fine modulus. Crushed stone particles are larger than 4.75 mm are referred to as coarse aggregates. Crushed stone from a nearby licensed quarry was used in this experiment.20mm coarse aggregate is a maximum size and specific gravity and fine modulus are 2.85 and 7.1 respectively.

Fibers

In this experimental investigation steel fibers, glass and carbon fibers were studied. The properties of the fibers are given in Table 1.

Table 1: *Properties of the Fibers*

Fibers	**Steel fiber**	**Glass fiber**	**Carbon fiber**
Length, [mm]	5	5	5
Diameter, [μm]	60	10	36
Density, [g/cm3]	7.9	2.4	0.95
Modulus, [GPa]	200	72	117.3
Tensile strength, [MPa]	970	1700	2588

Mix proportion

The proportion of mixture was done according to the Indian standard recommend (refer with: IS 10262-2009). Concrete is one of the most commonly utilized construction material. Concrete is a mixture of cement, sand, coarse aggregate, and water. By substation pozzolana (fly ash, silica fume, rice husk ash crushed granulated blast furnace slag) for cement, the cost of concrete is reduced [11]. The binder content in the mix was 383kg/m^3 of PPC cement, then the fine aggregate was taken for mixture is 672 kg/m^3 and the coarse aggregate are taken for mixture is 1100kg/m^3. M20 grade of concrete for mix proportion was1:1.75:2.87 by water cement ratio with weight of 0.5was kept as content. The variable percentage of steel, glass and carbon fiber from 0 to 2.5% of cement in volume batching with the incremental of 0.5.Cement, coarse and fine aggregate they properly mixed together to achieved homogenous before water was added. Totally 5 minute was mixing time of the mixture, the sample was casted, kept for 24 hour before demodulating. Until the day of testing, the sample was place in the curing tank. In the specimens, the compressive strength was containing fiber were cured in the tank for 7 days, and for compressive, tensile and flexural strength, the specimens were cured for 28 days.

Result and Discussion

Compressive strength

The compressive strength of the concrete arrived by crushing the cube of size 150mm at a period of seventh day and twenty eighth day. The compressive strength was the ratio of cross sectional area to ultimate load of the concrete. The average values of the three specimen of fiber reinforced concrete (FRC) (refer with table 2). In seventh day of curing, the average compression strength of the steel fiber reinforced concrete (SFRC) has higher than the glass fiber reinforced concrete (GFRC) as well as carbon fiber reinforced concrete (CFRC). The glass fiber reinforced concrete (GFRC) has a higher than the average compression strength carbon fiber reinforced concrete (CFRC). The graphical representation of average compressive of (FRC) at seventh day (refer with: Figure 1). In twenty eight days of curing, average compression strength of the steel fiber reinforced concrete (SFRC) higher than the glass fiber reinforced concrete (GFRC) as well as carbon fiber reinforced concrete (CFRC). Glass fiber reinforced concrete (GFRC) has higher average compression strength than carbon fiber reinforced concrete (CRFC). The average compressive strength of FRC at twenty eighth day (refer with: Figure 2).

Table 2: *Average Compression strength of FRC*

Sl.No.	% of Fiber	Average Compression strength [MPa]					
		SFRC		GFRC		CFRC	
		7^{th}	28^{th}	7^{th}	28^{th}	7^{th}	28^{th}
1	0.50	25.32	34.69	24.83	34.01	24.29	33.67
2	1.00	26.08	35.72	25.14	34.77	24.94	34.07
3	1.50	26.22	36.26	25.48	35.28	24.96	34.58
4	2.00	26.88	36.99	25.84	35.53	25.04	34.82
5	2.50	27.44	37.63	25.50	35.72	25.38	35.01

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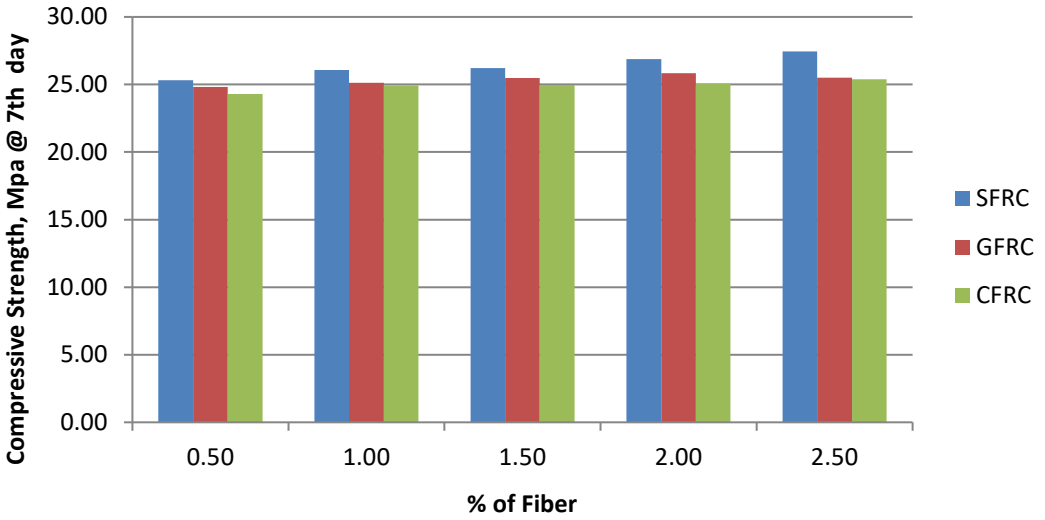

***Figure 1**: Average compressive strength of FRC at 7days*

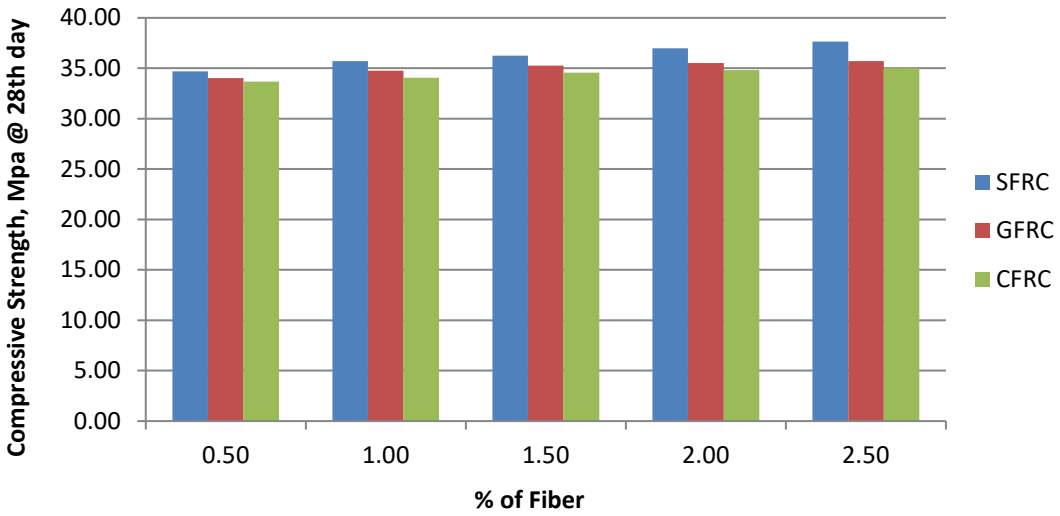

***Figure2**: Average compressive strength of FRC at 28 days*

The percentage of the fiber increase, compression strength of the Fiber reinforced concrete (FRC) increases. Incremental of compression strength of; SFRC was varied from 0 to 16 percentage, GFRC was varied from 0 to 10 percentage and CFRC was varied from 0 to 8 percentage for variable percentage of fiber in concrete. Graphical representation of incremental of compression strength is given. (refer with figure 3)

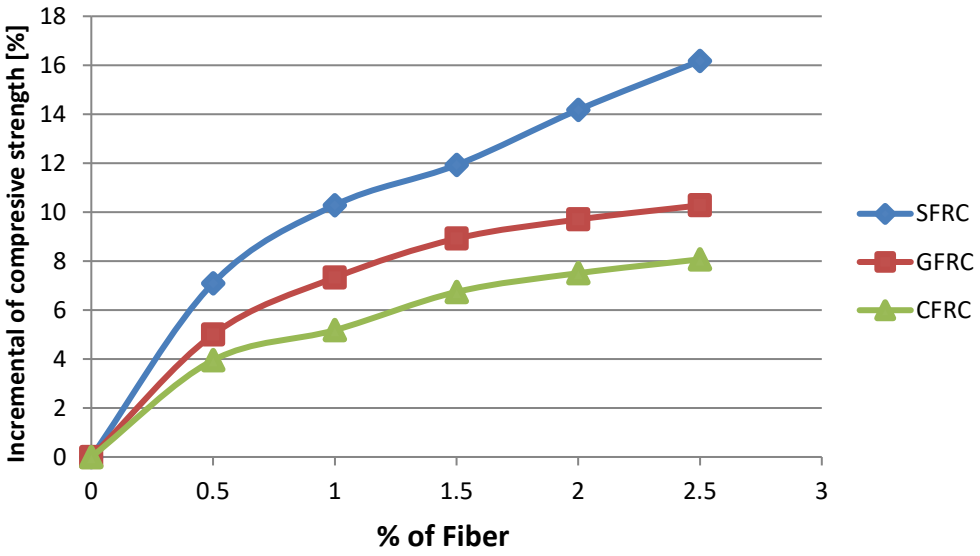

***Figure3**: Incremental of Compression Strength of FRC*

Split tensile strength

The cylinder was used to forecast tensile strength. A cylinder having a crushing strength, with a diameter of 150mm and a depth or height of 300mm is used to define and determine the concrete's strength. The specimen is placed lengthwise in the cylinder and the force is applied by machine. Tested the cylinder of steel fiber, glass fiber, carbon fiber the tensile strength was represented in the MPa. The cylinder's cross section area is 235 sq. cm. Finally, the tensile strength was the ratio of cross sectional area to ultimate load of the concrete. (refer with IS 516-1959) was used to record the highest load was applied to the cylinder. The cylinders ware put through tensile testing, and the tensile strength ware computed. The average values of three specimen of fiber reinforced concrete (FRC) (refer with Table: 3). In 28 days, the average tensile strength of the steel fiber reinforced concrete (SFRC) higher than the carbon fiber reinforced concrete (CFRC) as well as glass fiber reinforced concrete (GFRC). Carbon fiber reinforced concrete (CFRC) has a higher average Tensile strength than the glass fiber reinforced concrete. The average split tensile strength at 28 days (refer with: figure: 4)

***Table 3:** Average split tensile strength and Flexural strength at 28th day.*

Sl.No	% of Fiber	Average split tensile strength, [MPa]			Average flexural strength, [MPa]		
		SFRC	GFRC	CFC	SFRC	GFRC	CFRC
1	0.5	2.57	2.52	2.54	4.71	4.56	4.64
2	1	3.13	2.86	3.03	5.56	4.87	5.22
3	1.5	3.62	3.11	3.34	6.16	5.39	5.77
4	2	3.87	3.38	3.64	6.65	5.82	6.23
5	2.5	4.20	3.46	3.92	7.27	5.911	6.59

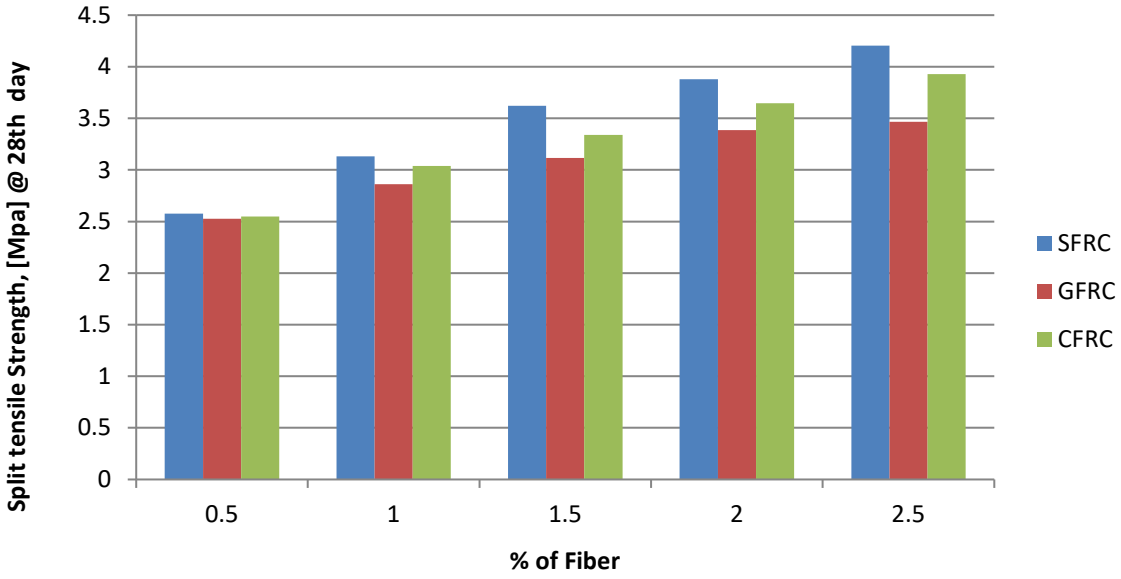

Figure 4: *Average Tensile strength FRC at 28 days*

Incremental of split tensile strength of; SFRC was varied from 0 to 80 percentage, GFRC was varied from 0 to 48 percentage and CFRC was varied from 0 to 68 percentage for variable percentage of fiber in concrete. Graphical representation of incremental of split tensile strength is given (refer with: figure 5).

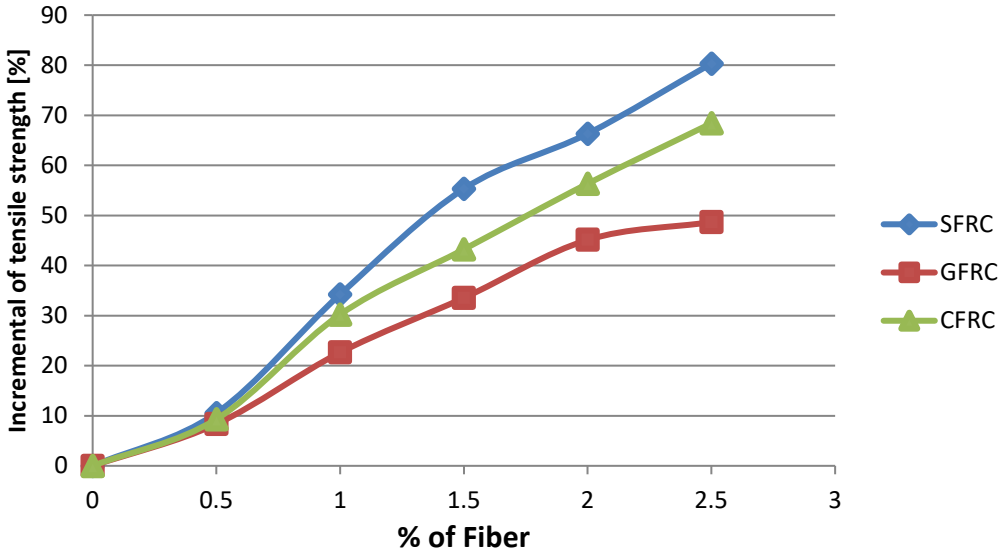

Figure 5: *Incremental of Tensile Strength of FRC*

Flexural strength

Flexural strength was predicted by using prism in the dimensions of (100mmx100mmx500mm). The flexural behavior of materials subjected to simple beam loading using the flexural method. With some materials, it's also named as a transverse beam test. Each increment of loading, maximum strain and maximum fiber stress are determined. The test result of flexural strength prism of steel fiber, glass fiber, carbon fiber are (refer with Table 3). The flexural strength was represented in the [MPa].The cross section area of the prism is 225sq.cm. (Refer with: IS 516-

1959) was used to record the highest load applied to the specimen. In 28th day of the average flexural strength of the steel fiber reinforced concrete (SFRC) comparatively greater than the carbon fiber reinforced concrete (CFRC) as well as glass fiber reinforced concrete (GFRC) (refer with: Figure 6). Carbon fiber reinforced concrete (CFRC) has a higher average flexural strength than glass fiber reinforced concrete (GFRC)

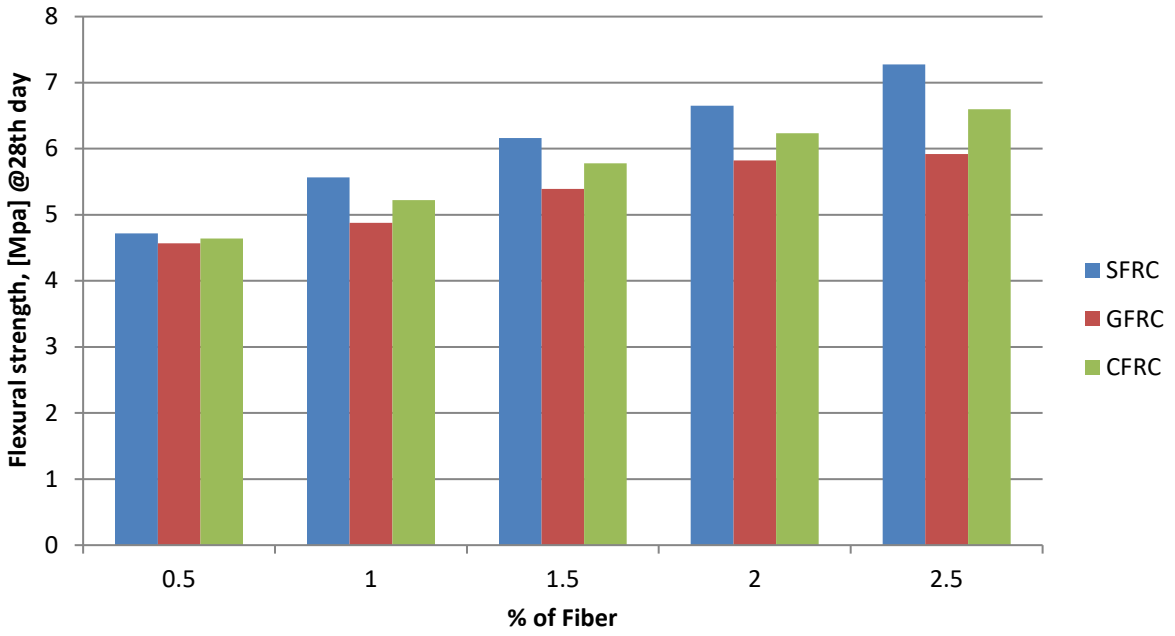

***Figure 6**: Average Flexural strength of FRC at 28 days*

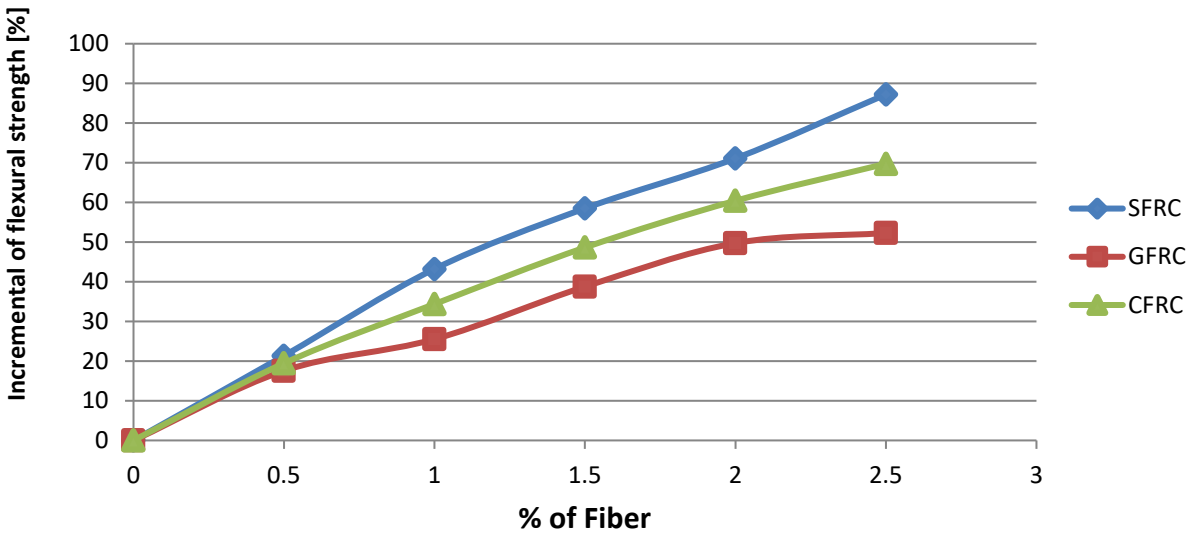

***Figure7:** Incremental of flexural strength of FRC*

The percentage of the fiber increase, flexural strength of the fiber reinforced concrete (FRC) also increases. Incremental of flexural strength of; SFRC was varied from 0 to 87 percentage, GFRC was varied from 0 to 52 percentage and CFRC was varied from 0 to 69 percentage for

variable percentage of fiber in concrete. The figure 7 shown the incremental of flexural strength of FRC.

Conclusion

In the fiber reinforced concrete has a component like steel glass and carbon with the specimen of cube, cylinder and prism respectively

1. The average compressive strength of the steel fiber reinforced concrete had higher than the glass fiber reinforced concrete as well as carbon fiber reinforced concrete at 7 days. The glass fiber reinforced concrete has a highest average compressive strength than the carbon fiber reinforced concrete at 7 days
2. The average compressive strength of glass fiber reinforced concrete and carbon fiber reinforced concrete had a less than the steel fiber reinforced concrete at 28 days. The glass fiber reinforced concrete has a highest average compressive strength than the carbon fiber reinforced concrete at 28 days
3. Incremental of compression strength of; SFRC was varied from 0 to 16 percentage, GFRC was varied from 0 to 10 percentage and CFRC was varied from 0 to 8 percentage for variable percentage of fiber in concrete.
4. The average split tensile strength of the SFRC had a higher than the CFRC as well as GFRC at 28 days. CFRC has a highest average tensile strength than the GFRC at 28 days.
5. Incremental of split tensile strength of; SFRC was varied from 0 to 80 percentage, GFRC was varied from 0 to 48 percentage and CFRC was varied from 0 to 68 percentage for variable percentage of fiber in concrete.
6. The average flexural strength of the SFRC had a higher than the CFRC as well as GFRC at twenty eight days of curing. CFRC has a highest average flexural strength than the GFRC at 28 days
7. Incremental of flexural strength of; SFRC was varied from 0 to 87 percentage, GFRC was varied from 0 to 52 percentage and CFRC was varied from 0 to 69 percentage for variable percentage of fiber in concrete.

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