International Journal of Multidisciplinary and Current Research ISSN: 2321-3124

Research Article Available at: http://ijmcr.com

Mechanical Behaviour of Cement Concrete using Fibres

Gaurav Vats[*], Preeti Kuhar^ and Sanjeev Kumar[!*]

[#]M.Tech Student, [^]Assistant Professor, Department of Civil Engineering, RP Educational Trust, Bastara, Karnal, India
[!]Ph.D Student, Thapar Institute of Engineering and Technology, Patiala, India

Received 25 May 2018, Accepted 27 July 2018, Available online 30 July 2018, **Vol.6 (July/Aug 2018 issue)**

Abstract

Concrete is the most used material for the construction in the modern time of infrastructures. Concrete is strong in compression but it is weak in tension and shear. To minimise those problems, fibres were introduced in concrete to enhance its tensile strength and shear strength. In my present investigation, the mechanical properties of fibres reinforced concrete are studied by using steel fibre, glass fibre and polyamide fibre with a different weight fraction of fibres with respect to cement. The mix design of M25 concrete with W/C ratio of 0.42 is prepared and total thirteen mixes included one control mix was prepared and tested in the laboratory. The total quantity of fibres mixed in the concrete are in order of 0%, 0.75%, 1.5%, and 2.25% by weight of cement and one mix contains 0.33% of glass fibre, 0.33% of steel fibre and 0.33% of polyamide. The study shows that the mixed fibres provide better properties in controlling cracks and high strengths than single fibre and concrete without fibre. On increasing the percentage of fibres beyond 1.5%, the strength of the concrete matrix decrease due to mat form of fibres or non-uniform distribution of fibres and also decrease due to non-cohesiveness of the concrete particle to each other.

Keywords: *Glass Fibre, Steel Fibre, Polyamide fibre, compressive strength, split tensile strength, flexural strength.*

1. Introduction

Fibre reinforced concrete (FRC) may be defined as a composite material made with Portland cement, aggregate, and incorporating discrete discontinuous fibres. The fibres used in the concrete may be the natural or manufactured product: asbestos, sisal, cellulose, glass, steel, polypropylene, carbon, polymer and Kevlar. Normally plain concrete does not give as much tensile strength as compared to compressive force. This is the main drawback in plain concrete and is necessary for the civil engineer to use conventional reinforcement to improve ductility and tensile strength of the concrete member. Such type of composite material is called fibre reinforced concrete.

The idea for which that plain concrete can be strengthened by mixing fibres was first put forward in 1910 by the porter. While polypropylene fibre is suitable for improving the impact strength of the concrete, whereas steel fibre is responsible to improve flexural strength and split tensile strength of the plain concrete. The glass fibre provides greater resistance from propagation and occurrence of early cracks. (Rajagopalan *et al.* 1974).

*Corresponding author's ORCID ID: 0000-0002-2283-2444
DOI: https://doi.org/10.14741/ijmcr/v.6.4.24

Glass fibre is also important in those respects but corroded in an alkaline environment in the concrete. Sometime in bridges and pavement, flexural fatigue strength is the important parameter and it is designed on the basis of fatigue loading.one more advantage of adding fibres in the concrete gives the higher fatigue strength. Mixing of steel fibre in plain concrete gives the formation of a concrete composite having improved ductility and high energy absorption capacity composite (stiffness). However due to the inherent property of fibrous concrete-the presence of fibres in concrete can be expected to increase the resistance of conventional reinforced structural member against deflection, cracks and service life of concrete (Chanh 2004).

2. Experimental Programme

2.1 Material and mixture proportion

Ordinary Portland cement (OPC) having specific gravity 3.15 is used as a binder. Locally available river sand and crushed coarse aggregates are used. The specific gravity of fine and coarse aggregates is 2.47 and 2.63 respectively. In the present experimental investigations, water-reducer based superplasticizer (sikament) was used for enhancing workability. The amount or superplasticisers was 1.5% by weight of cement. Normal tap water used for mixing.

Steel fibre, Polyamide fibre and Glass fibre are used in different proportions and different aspect ratios to enhance the mechanical strength of the concrete. The specific gravity of these fires is 7.86, 1.16, and 1.35 respectively. The properties of these fibres are given in the table.

Table: 1 Property of fibres

S.no	Fibre	Product name	Length (mm)	Aspect ratio
1	Recron Glass fibre	Triangular Polyester	12	480
2	Steel fibre	Hooked end	35	50
3	Polyamide fibre	Naplon	15	518

2.2 Mixing procedure and specimen preparation

Thirteen mixes of concrete with 0%, 0.75%, 1.5%, 2.25%, weight of glass fibres, steel fibres and polyamide fibres were adopted for this experimental work. The ratio for course to fine aggregate is 50:50 for all mixes. In order to improve the workability of the concrete, the superplastisizer is added by 1.5 % of the weight of cement throughout the Experiment. Concrete is mixed with ordinary Portland cement (OPC) of grade 43.The mix design ratio of experiment is 1:1.3:3 by weight with water-ratio cement of 0.42. The average standard compressive strength after 28 days of concrete is approximately 24Mpa for M25 grade of concrete.

Concrete cube of size 150mm*150mm*150mm were casted for determining the compressive strength of concrete. Cylindrical concrete specimen having dimension 150mm diameter and 300mm height were casted to determine the split tensile strength of concrete. Beam specimens of size 100mm*100mm*500mm were casted to find the modulus of rupture.

2.3 *Testing procedure*

Performance of structural concrete generally depends upon strength in tension, compression, and flexural. So it is necessary to determine these properties. The tests carried on fibre based concrete are discussed as under: Compressive strength test of concrete is measured on 150 mm*150mm*150mm cubes of standard size as shown in the figure 3. A compressive testing machine (CTM) with capacity of 3000 KN at loading rate 5.25 KN per second is used. The average compressive strength of three cubes is taken for each test, and the test were conducted at age of 7 days and 28 days.

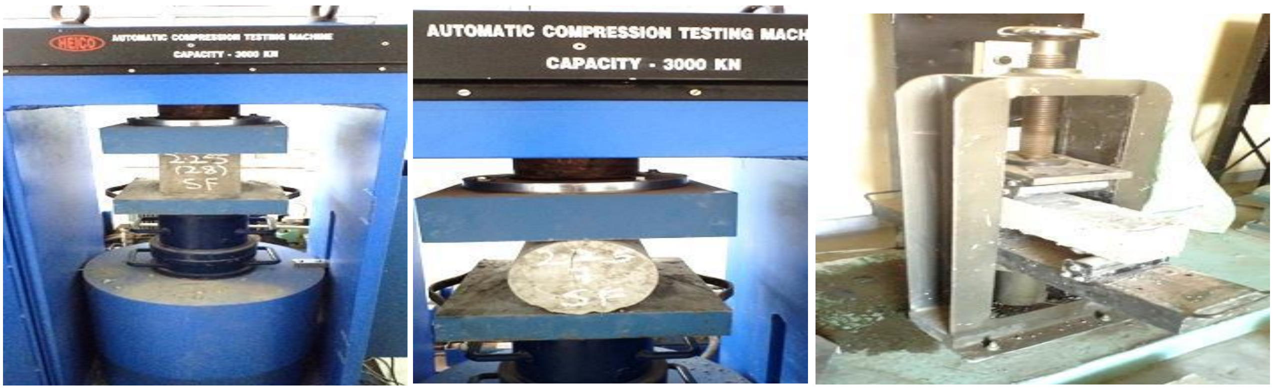

Figure: 1 (a) CTM for compression test**, (b)** CTM for split tensile strength test**, (c)** Flexural testing machine

The split tensile strength of cylindrical concrete specimens of size 150mm*300mm is also determine in compressive testing machine. As shown in Figure 3…., a compressive testing machine (CTM) with capacity of 3000 KN at loading rate 5.25 KN per second is used. Three identical specimens of concrete were casted in all the mixtures and for the entire test the average results of three specimens are taken.

According to code, IS: 9399-1979, flexural strength of 100mm*100mm*500mm prisms are tested in flexural testing machine. The specimen is tested at the age of 7 days and 28 days and the average of three specimens are taken as the flexure strength of concrete.

3. Results and Analysis

Specimen corresponding to fibre reinforced concrete and conventional concrete mixes were subjected to various type of tests to determine the effect of fibres on concrete for various mechanical properties of concrete like split tensile strength, compressive strength, and flexural strength.

The testing results after 7 days and 28 days of all the specimen were shown in tabular form. On the basis of experimental value obtained, the graphical results were also shown that shows the comparison between the glass, steel and polyamide fibres.

The increase or decrease in the properties of concrete is also determined when fibres are mixed into concrete with respect to plain concrete by using equation as under.

$$\frac{Finalvalue - initialvalue}{finalvlue} * 100$$

Table: 2 Compressive strength, split tensile and flexural strength of plain concrete after 7 and 28 days

S.no	Fibre %age	Average Compressive Strength (N/mm2)		Average Split tensile Strength (N/mm^2)		Average Flexural Strength (N/mm2)	
		7 Days	28 Days	7 Days	28 Days	7 Days	28 Days
1	0	14	20.10	2.81	3.77	4.35	5.91

Table: 3 Compressive strength, split tensile and flexural strength of Glass fibre concrete after 7 and 28 days

S.no	Fibre %age	Average Compressive Strength (N/mm2)		Average Split tensile Strength (N/mm^2)		Average Flexural Strength (N/mm2)	
		7 Days	28 Days	7 Days	28 Days	7 Days	28 Days
1	0.75	18.10	21.64	2.69	4.05	5.25	6.41
2	1.50	19.25	26.14	2.90	4.55	6.61	7.55
3	2.25	18.94	27.22	2.80	4.53	6.15	7.33

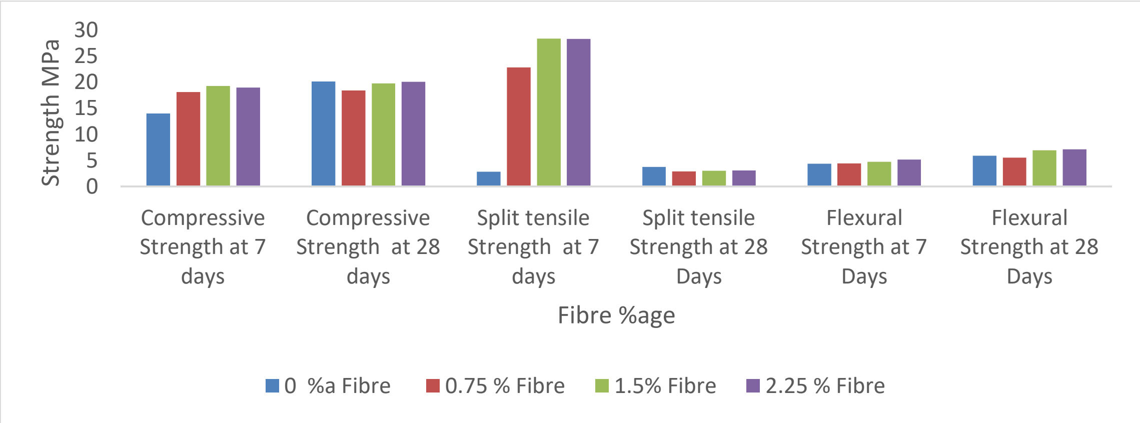

Figure: 2 Compressive strength, split tensile and flexural strength of Glass fibre concrete after 7 and 28 days

Table: 4 Compressive strength, split tensile and flexural strength of Steel fibre concrete after 7 and 28 days

S.no	Fibre %age	Average Compressive Strength (N/mm2)		Average Split tensile Strength (N/mm^2)		Average Flexural Strength (N/mm2)	
		7 Days	28 Days	7 Days	28 Days	7 Days	28 Days
1	0.75	18.13	21.704	2.84	4.29	5.15	6.61
2	1.50	19.48	28.015	2.87	4.68	6.55	7.73
3	2.25	19.45	27.393	2.82	4.55	6.16	7.44

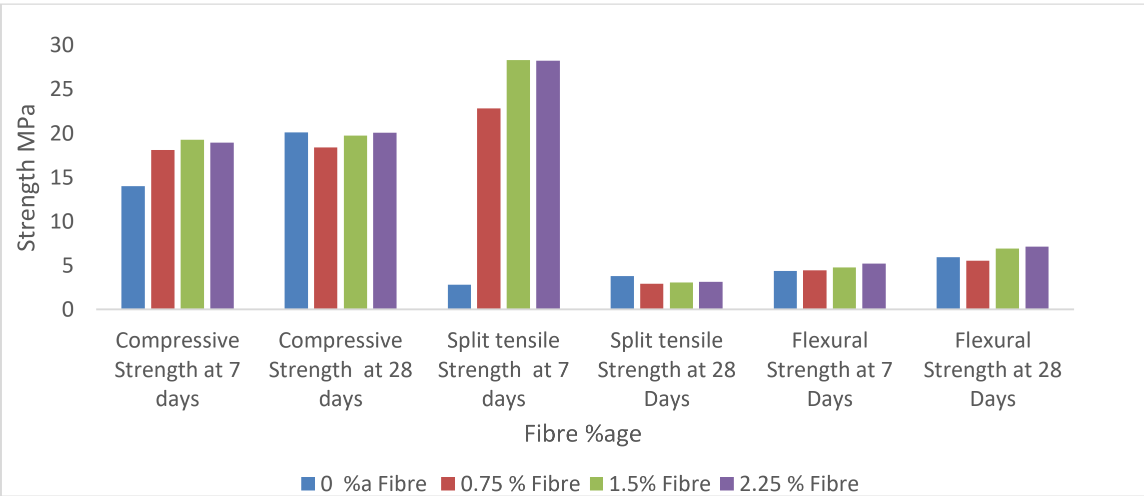

Figure: 3 Compressive strength, split tensile and flexural strength of Steel fibre concrete after 7 and 28 days

Table: 5 Compressive strength, split tensile and flexural strength of Polyamide fibre concrete after 7 and 28 days

S.no	Fibre %age	Average Compressive Strength (N/mm2)		Average Split tensile Strength (N/mm^2)		Average Flexural Strength (N/mm2)	
		7 Days	28 Days	7 Days	28 Days	7 Days	28 Days
1	0.75	17.73	21.57	2.81	4.17	5.23	6.53
2	1.50	19.06	25.41	2.99	4.59	6.33	7.33
3	2.25	18.82	26.12	2.86	4.33	6.16	7.16

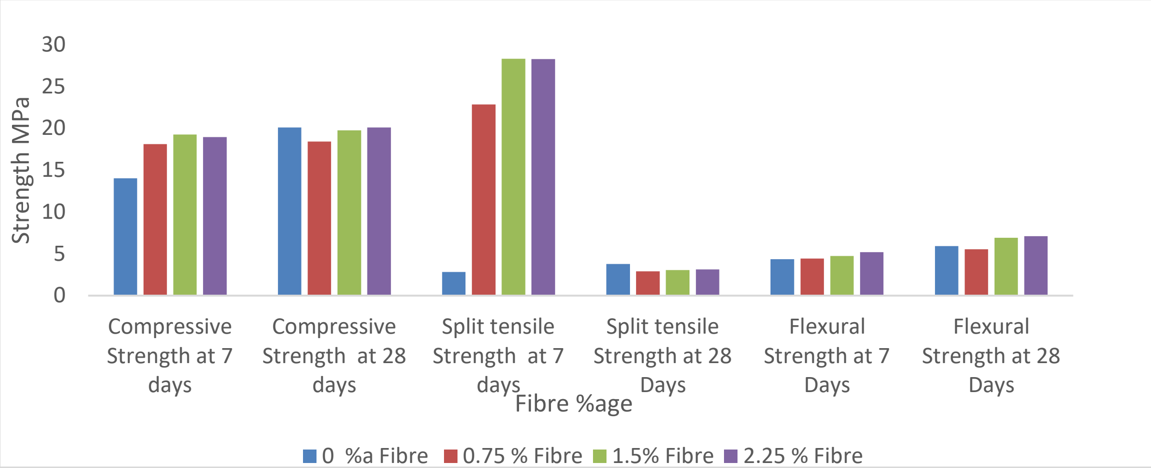

Figure: 4 Compressive strength, split tensile and flexural strength of Polyamide fibre concrete after 7 and 28 days

Table: 6 Compressive strength, split tensile and flexural strength of (steel +glass+ polyamide) fibre concrete after 7 and 28 days

S.no	Fibre %age	Average Compressive Strength (N/mm2)		Average Split tensile Strength (N/mm^2)		Average Flexural Strength (N/mm2)	
		7 Days	28 Days	7 Days	28 Days	7 Days	28 Days
1	0.75	18.40	22.84	2.89	4.43	5.53	7.11
2	1.50	19.74	28.32	3.04	4.74	6.91	8.11
3	2.25	20.08	28.25	3.11	5.18	7.11	8.28

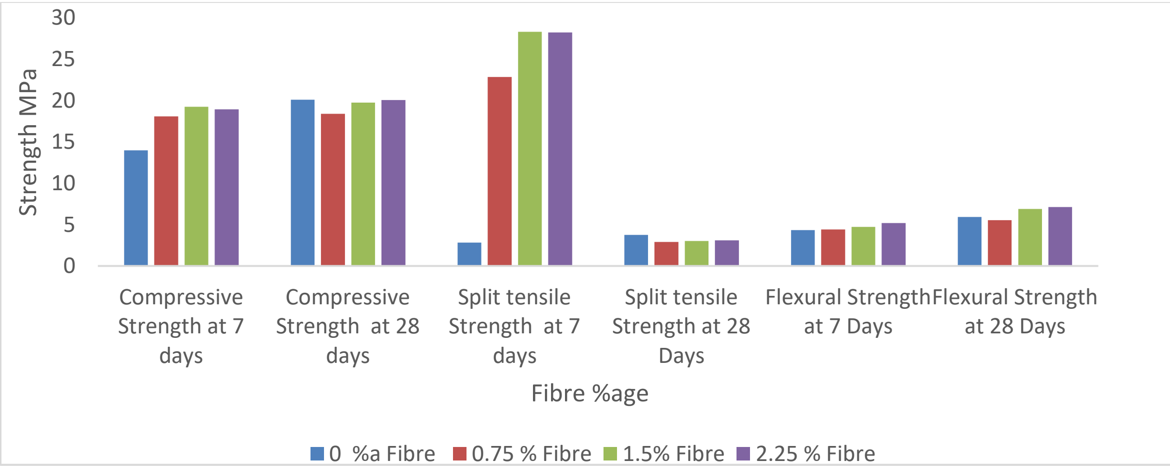

Figure: 5 Compressive strength, split tensile and flexural strength of (steel +glass+ polyamide) fibre concrete after 7 and 28 days

Conclusion

- Fibers provide a safer working environment.
- The addition of fiber in concrete convert brittle nature into ductile nature.
- Flexural strength of concrete is largely affected by adding fibers in concrete almost increase up to 160%.
- Split tensile strength of glass fiber is very low as compare to normal mix.

- It should be seen that the compressive strength of steel, glass, and polyamide fiber is almost same.
- Higher percentages of fibres from 1.5 percentages affect the workability of concrete, and decrease the strength of concrete matrix.
- 1.50% Dual fibre volume can be taken as the optimum dosage.
- By using these fiber, maximum strength should be obtained at 1.5 % of fibers.
- Tensile, and flexural behavior of concrete should be different for different type of fibres.
- The maximum size of course aggregate in concrete should not be more than 10mm to 20mm for better result.
- The concrete mix design should not be affected by the addition of fibers.
- Fibers at lower quantity and reasonable cost fulfill all the require condition of the concrete.
- There is no proper maintenance require during addition into the concrete.
- By using mixture of two or more fibres above 1.5 percent in concrete compressive strength do not affected but split tensile strength and flexural strength of concrete increase.

Acknowledgement

The authors appreciate Mr. Sanjeev Kumar for his kind support in conducting the experimental work

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