EXPERIMENTAL STUDIES ON EFFECT OF DIFFERENT FIBERS ON THE BEHAVIOUR OF STRUCTURAL COMPONENT

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ABSTRACT

Concrete plays a very important role in construction industry. In last few decades, many researchers have tried to understand the behavior of concrete under different climate condition, loading condition, freeze-thaw effect, sulphate attack, chloride attack, carbonation etc. Improvement in structural properties of concrete became main area of interest. Many scientists and researchers started experimenting concrete by adding discrete discontinuities fiber, popularly known as fiber reinforced concrete so as to study the effect on mechanical and durability properties of concrete. In present study, different fiber such as steel, polypropylene and glass having different volume fraction were considered so as to study the effect of them on RC beam. Crack pattern, initial cracking load, ultimate load carrying capacity, maximum deflection of beam were studied for different percentage of steel, polypropylene and glass fiber. Effective and efficient performance of structural elements was determined for different percentage of different fiber so that optimum percentage can be calculated for each fiber.

Keywords: Fibre Reinforced Concrete; Steel; Polypropylene; Glass: Ultimate Load Carrying Capacity

I. INTRODUCTION

Concrete is most widely used construction material in the world. Concrete is good in compression but weak in tension. Ordinary cement concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. Internal micro cracks, leading to brittle failure of concrete.. Many researches are carried out to improve the brittle fracture behavior of concrete by adding new ingredient to concrete mix. Addition of discrete discontinuities fiber to cement, water, fine and coarse aggregates to form a composite material is called fiber reinforced concrete.

Addition of fiber to concrete helps to control cracks occurring due to drying and plastic shrinkage, reduce the permeability and thus reduce bleeding of water. Depending upon the type of fibers added to concrete mix, it increases the impact and abrasion resistance in concrete. Fiber plays a very important role in improving the mechanical properties of concrete such as compressive strength, ultimate load carrying capacity of structures etc. It helps to increase corrosion resistance, increase tensile strength, increase ductility and thus helps in increasing the durability of concrete structures. Thus, it can be said that the brittle fracture behavior of concrete is converted to ductile behavior to some extent by addition of fiber.The amount of fibers added to a concrete mix is expressed as a percentage of the total volume of the composite (concrete and fibers), termed "volume fraction".

In this paper, an experimental investigation is done to understand the effect of different volume fraction of different fiber like steel, polypropylene and glass on structural behavior of RC beam.

Crimped Steel Fibres **Polypropylene Fibres** **E-Glass Fibres**

II .EXPERIMENTAL STUDY

Three point bending Tests were conducted on simply supported RC beams having different volume fraction to estimates the mechanical properties, load at initial crack, deflection of beam at various loading condition and finally ultimate load estimation.

2.1 Material Properties, Mixes, Beams

Concrete mixes were designed with the grades of compressive strength according to the Indian standards [IS 10262:2009 & IS 456:2000]. The mix were made of ordinary Portland cement 53grade, natural sand, crushed aggregate size below 12mm and potable water, (Normal strength concrete, NSC). The NSC mix proportion by weight of cement, fine aggregates, coarse aggregates and water were taken as 1:1.87:3.37:0.42. andsuperplasticizer 1% adopted in mix. The same mix proportion was adopted for different fiber. Volume fraction of steel fiber added was 0.5%, 1% and 1.5% in concrete mix. Volume fraction of polypropylene fiber was 0.2%, 0.4% and 0.6%. Volume fraction of glass fiber was 0.3%, 0.6% and 1.0 %. The specimen preparation was strictly controlled to minimize the scatter in the test results. The NSC specimens were demoulded after 1 day and cured in a water tank at ambient temperature for 28 days. RC beams of 100x200 mm in cross section and length 1 m were casted and tested to estimate initial crack load and ultimate load carrying capacity. Figure a, b and c represent the casted RC beams with different volume fraction of steel, polypropylene and glass fibre as specified above respectively.

Fig a

Fig b

Fig c

Fig d

Figure 1:RC beam casted with different volume fraction of fiber(a) steel fiber (b) polypropylene fiber(c)E Glass fibre(d)Rc Beam with no fibre.

Table 1: Fibres properties

Materials	Density (kg/m3)	Length (mm)	Diameter (mm)	Tensile Strength (Mpa)
Steel Fibre	900	12	0.038	330-414
Polypropylene Fibre	7900	50	1.0	850
E-Glass Fibre	2540-2600	12	0.007	3445

III EXPERIMENTAL SETUP AND TEST PROCEDURES

RC beams were simply supported over a clear span of 0.99m and tested under three point bending, as shown in figure 2. Figure 2 represent the experimental setup for testing of RC beam under three point bending. Figure 3 shows the Universal Testing Machine, which was used for testing all the specimen without and with fiber RC beams. Figure 4 shows the arrangement of strain gauge under the loading point which is centre, for estimating the centre deflection of the RC beam under incremental load at centre of specimen in three point bending. The load is applied in incremental order of 5kN. The corresponding deflection was noted down as well as the crack pattern was observed for understanding the characteristic behavior change in RC beam under different volume fraction. Estimation of load at initial crack for all specimen as well as ultimate load carrying capacity was determined.

Figure 2.Experimental setup for testing of RC beam under three point bending

Figure 3.Experimental setup of Strain gauge at centre of RC beam

Figure 4:UTM used for testing all specimen.

IV RESULTS AND DISCUSSION

In this study, RC beams having different volume fraction of steel, polypropylene and glass fibers were tested to understand the behavior on mechanical properties of beams with respect to controlled beam. The study was conducted to estimate increase in ultimate load carrying capacity and study of crack pattern of beam under same fiber but different percentage. The initial cracking load for controlled beam is 20kN and ultimate load carrying capacity is 50kN. Table 2 represents the initial cracking load for different volume fraction for steel, Polypropylene and glass fiber. It can be seen that there is no proper relationship with increase in fiber percentage and cracking load. Also table 2 gives us the ultimate load carrying capacity, and it can be observed that load carrying capacity increased with increased in steel fiber percentage from 0.5 % to 1.5% but opposite relationship is observed in case of polypropylene fiber , decrease in load carrying capacity. And in case of glass fiber, ultimate load increases and then decrease with increase in volume fraction.

Table 2: Initial and ultimate load for different fibers

Type of fiber	Volume fraction of fiber(%)	Initial Cracking Load(kN)	Ultimate Load(kN)
Steel	0.5	35	59.4
	1	30	61.4
	1.5	30	65.24
Polypropylene	0.2	22	64.1
	0.4	26	60
	0.6	21	59
Glass	0.3	23	54
	0.6	24	55
	1	21	51

Figure 5 represents the crack pattern in controlled RC beam. Figure 6 represents the crack pattern in RC beam consisting of different volume fraction of steel fiber. Figure 7 represents the crack pattern in RC beam consisting of different volume fraction of polypropylene fiber. Figure 8 represents the crack pattern in RC beam consisting of different volume fraction of glass fiber. It can be seen that number of crack reduced with increase in percentage of fiber content in RC beam. Crack pattern and crack propagation depends on many factor like tensile strength of RC beams, crack arresting properties (bridging action) which mainly depends on distribution and orientation of fiber present in beam, and also on bonding properties of fiber with cement matrix in concrete. The variation in initial cracking load in fiber reinforced concrete beam with respect to controlled beam for different fiber such as steel, polypropylene and glass are presented in figure 7, 8 and 9 respectively. The percentage increases in ultimate load carrying capacity in fiber reinforced concrete beam with respect to controlled RC beam for different fiber are plotted in figure 10, 11 and 12 for steel , polypropylene and glass fiber respectively

Figure 5:Cracked ControlledBeam

Figure 6: Cracked Steel Fibe

Figure 7:Cracked Polyproylene Fiber Reinforced Beam

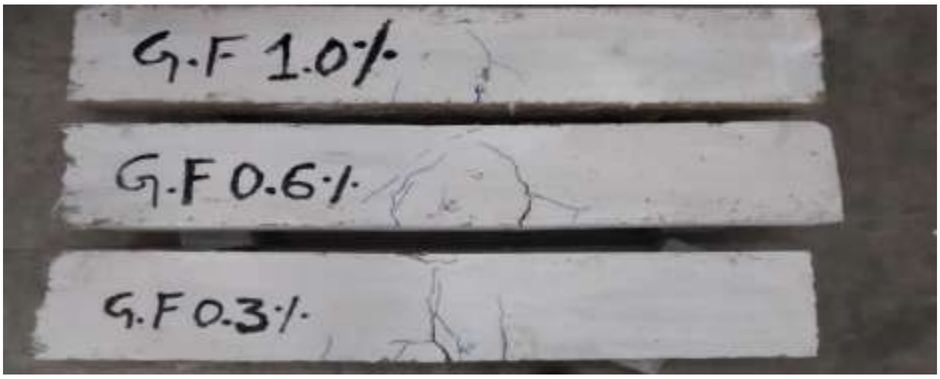

Figure 8:Cracked Glass Fiber Reinforced Beam

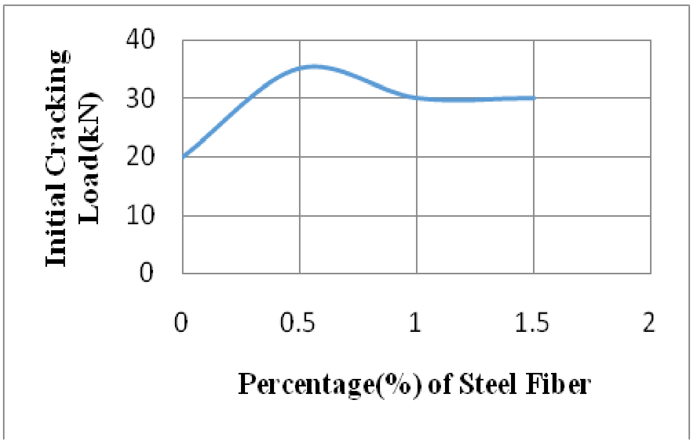

Figure 7: Variation of Initial Cracking Load in Steel Fiber Reinforced Beam.

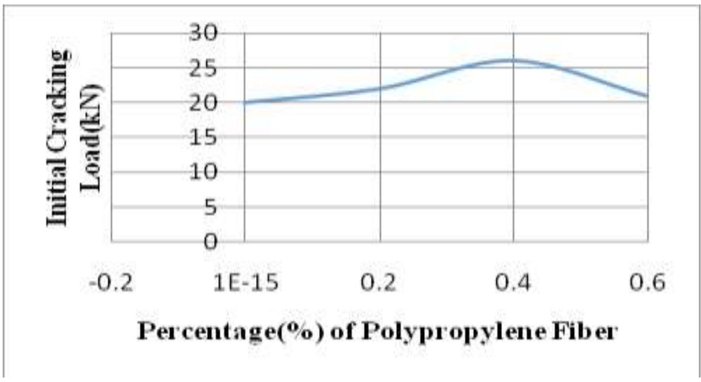

Figure 8: Variation of Initial Cracking Load in Polypropylene Fiber Reinforced Beam

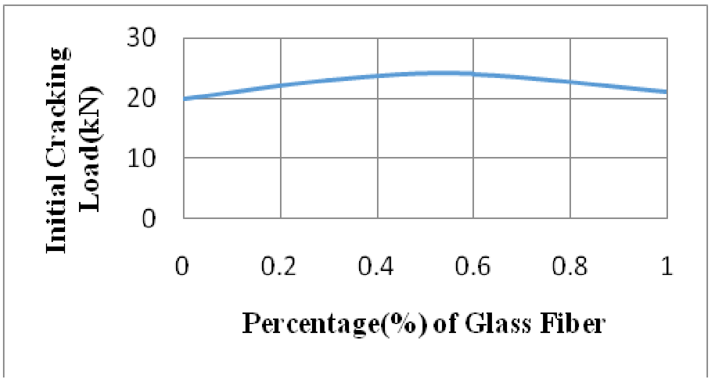

Figure 9: Variation of Initial Cracking Load in Glass Fiber Reinforced Beam

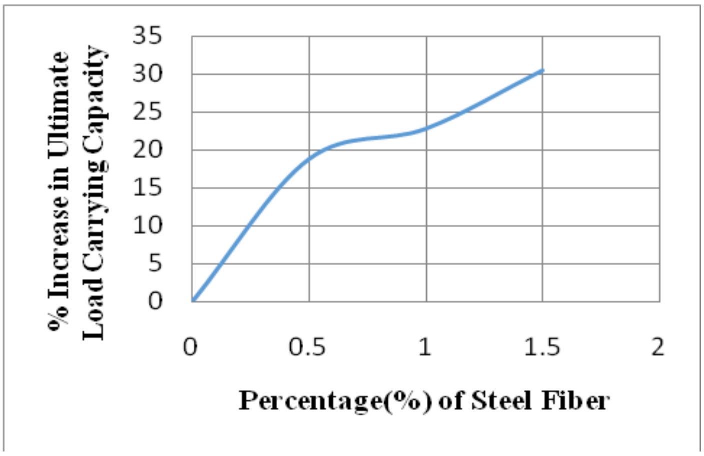

Figure 10: Percentage Variation in Ultimate Load Carrying capacity in Steel Fiber Reinforced Beam

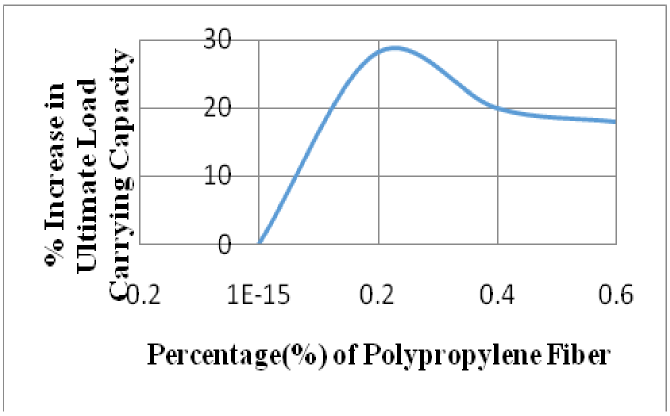

Figure 11: Percentage Variation in Ultimate Load Carrying capacity in Polypropylene Fiber Reinforced Beam

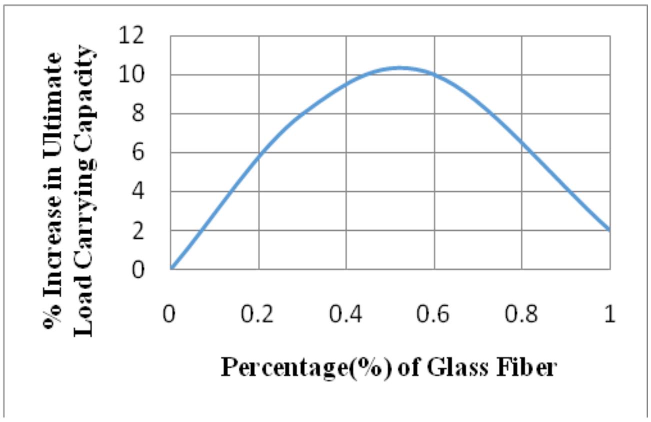

Figure 12: Percentage Variation in Ultimate Load Carrying capacity in Glass Fiber Reinforced Beam

V CONCLUSION

The experimental investigation has been undertaken to study the structural behavior of the RC beams with different fiber like steel , polypropylene and glass. Based on the results obtained, following conclusions can be drawn:

1. It can be observed that fiber reinforced concrete beam perform much better as compared to NSC beam in term of initial cracking load, ultimate load carrying capacity etc. Thus, it can be concluded that fiber reinforced beam helps to improvise the structural behavior such as tensile strength, converting brittle fracture behavior of concrete to ductile fracture behavior, ductility, flexural stiffness, toughness etc.

2. As the initial cracking load for steel fiber is much higher than controlled beam, polypropylene and glass fiber reinforced beam, it can be said that steel fiber are good in arresting the crack formation in RC beam as steel fiber are more good in improving the tensile strength and help in bonding the ingredient of concrete together for much higher load as compared to polypropylene and glass fiber. So, it can be concluded that bridging action of steel is much better than other two fibers.

3. There is variation in initial cracking load with different volume fraction of different fiber. This is because of the aspect ratio of different fiber used and the distribution and orientation of fiber throughout the RC beam. 0.5%, 0.4% and 0.6 % volume fraction of steel, Polypropylene and glass fiber give maximum initial cracking load respectively.

- It can be observed that increase in percentage of steel fibers there is increase in ultimate load carrying capacity. These is because, increase in volume fraction increase the tensile strength i.e. converting brittle behavior of concrete into ductile behavior. Steel fiber helps in arresting the crack and they are more effective in bridging the crack and thus beam perform better with increased in percentage from 0.5% to 1.5%. It can be seen that there is 30.48% increase in ultimate load carrying capacity when 1.5% volume fraction of steel fiber were present in RC beam.
- It can be observed that load carrying capacity increased and then decreased in polypropylene fiber. There is 30 % increase in initial cracking load for 0.4% volume fraction of polypropylene fiber. 0.2% of polypropylene fiber give maximum load carrying capacity 64.1kN. Thus, it can be concluded from above result that optimum percentage of polypropylene fiber which should be used is appropriately in range of 0.2% to 0.4%.
- 3.It can be observed that load carrying capacity increased and then decreased in glass fiber. There is 20 % increase in initial cracking load as well as we get maximum load carrying capacity as 55kN for 0.6% volume fraction of glass fiber. Thus, it can be concluded from above result that optimum percentage of glass fiber which should be used is appropriately 0.6%.
- With increase in percentage of fiber in RC beam, it can be observed that crack width and crack opening has reduced as well as crack propagation inside the beam has reduced, thus improving the behavior of beam such as by increasing the initial cracking load ,tensile strength . Ultimate load carrying capacity of beam and ductility.
- It can be concluded that volume fraction , aspect ratio ,distribution and orientation of fibres play a very important role in bridging effect, deflection of beam, crack width , crack propagation, initial cracking load and ultimate load carrying capacity.

Thus, we can conclude from the above study that steel fiber having volume fraction of 0.5% steel fiber give maximum initial cracking load and 1.5% of steel fiber give maximum ultimate load. So, steel fiber reinforced concrete beam give good performance as compared to other fiber. The optimum percentage of different fibers to get effective and efficient performance of structural element was determined in the above study

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