FLEXURAL BEHAVIOUR OF RC BEAM USING NYLON FIBER AND STEEL FIBER

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Abstract—Performance of Conventional concrete is enhanced by the additional of fibers in concrete. Adding a single type of fibre into concrete has limited functions, so many current researches are oriented to the development of hybrid fibre in concrete to obtain better mechanical properties. The main reason for steel and nylon fibre used in concrete matrix is to improve post cracking response of the concrete and to improve energy absorption capacity, ductility and to provide crack resistance and crack control. The introduction of concrete is brought in as a solution to develop concrete with enhanced flexural strength. In this study examines the flexural strength of concrete with two different types of fibre such as steel fibre and nylon fibre with fibre content of 0.75% of steel fibre is kept constant in each mixes and 1%, 2%,3% of nylon fibre was varied in each mixes. The tests are to be carried out with M30 grade and the results are to be compared between conventional concrete to fibre reinforced concrete.

Keywords—Steel Fibre, Nylon Fibre, Compression Strength, and Flexural Strength.

I. INTRODUCTION

Concrete‟s versatility, durability, and economy have made it the world‟s most used construction material. The India uses about 7.3 million cubic meters of ready-mixed concrete each year. Engineers are continually working on it, to improve its performance with the help of innovative supplementary or replacement materials. Cement, sand and aggregate are essential needs for any construction industry. Sand is a major material used for preparation of mortar and concrete and plays a most important role in mix design. Fiber Reinforced Concrete can be defined as a composite material consisting of mixtures of cement, mortar or concrete and discontinuous, discrete, uniformly dispersed suitable fibers. Incorporation of fiber in concrete has found to improve several properties like tensile strength, cracking resistance, impact and wear resistance, ductility and fatigue resistance.

This project shows the investigation on mechanical properties (compressive strength, split tensile strength, flexural strength) of Fiber nd better fatigue strength. Nylon fiber is selected as a replacement material to increase the tensile property of concrete and also it lowest density and light weight material in the fiber.

In this research, therefore, an attempt has been made to study the feasibility of using two kinds of fibres for making FRC. The beneficial effects of non-metallic fibres like nylon 6 is to arrest the propagation of micro cracks in the plastic stage of concrete due to their lower stiffness and increased fibre availability (because of lower density as compared to steel) at a given volume fraction. It is important to have a combination of low modulus (nylon 6) and high modulus fibres (steel) to arrest the micro and macro cracks, respectively.

2.LITERATURE REVIEW

Magorzata Pajka presented a Paper on “Experimental investigation on hybrid steel fibers reinforced self-compacting concrete under flexure”. Usingthe self-compacting concrete (SCC) can shorten the time and decrease the costsof the building process. The incorporation of the randomly distributed steelfibers into brittle SCC improves its tensile parameters. The steel fibers can be effective in delaying propagation of micro- or macro-cracks according to geometrical parameters of fibers. To attract all types of cracks the fibers withdifferent geometrical

parameters should be used simultaneously. In the presentpaper, the influence of the combinations of straight and corrugated steel fiberswith different lengths (6 mm, 35 mm) and cross-sectional shape on thecompressive strength and flexural behavior of SCC was investigated. The totalfibers volume ratio varied from 1.0 % to 3.0 %. Among the rheological parameters of self-compacting concrete, the hybrid fibers reinforcement did notinfluence workability but pronouncedly decreased passing ability. Thus, the mixes reinforced with the highest fibers volume ratios did not satisfy the requirements for the SCC. Based on the mechanical test results no apparent difference in the compressive strength was noted. The results showed that the flexural parameters were pronouncedly enhanced in the HFR-SCC due to the hybrid fiber addition and at low dosage rates depended on the proportions between the two applied types of fibers. However, using the highest summary amounts of fibers did not cause furtherincrease

.**N.V.N.Prabath,Dr.P.Ramados**s presented a paper on "EVALUATION OF MECHANICAL PROPERTIES AND FLEXURE BEHAVIOUR OF HIGH PERFORMANCE HYBRID FIBREREINFORCED CONCRETE – A REVIEW".High-performance concrete (HPC) is a material frequently used in the building industry due to its durability. Concrete technology has developed at a rapid pace over the last two decades and the material performance has been significantly improved. Now a day, there are numerous types of fibres made of
different materials that are of different geometric properties. With each type of fibre certain properties of concrete can be improved. In order to improve mechanical properties, especially the tensile and flexural strengths and longterm concrete shrinkage, steel fibres' are usually used. One of the recent concepts is the hybridization of fibres, the optimum combination of several 5 kinds of fibres with different properties to create a complex composite with a very high resistance to cracking in a wide range of crack width. A lot of research revealed that a hybrid of steel and polypropylene fibre in concrete exhibits composite advantages of the two-fibre material properties, improves the interface condition between cement and aggregate, enhances the medium continuity of concrete, and constraints the occurrence and development of concrete cracks. Present study focussed on the rational development of researches on hybrid fibres from past decades and objectives of future enhancement.

E. Siva Subramanian, V.R. Vaishnave, V.T.S Vignesh presented a paper on "EXPERIMENTAL INVESTIGATION OF CONCRETE COMPOSITE USING NYLON FIBRE". Nylon fiber is not an absolutely new material, it is successfully applied in such fields as mostly found in garment interlinings, tooth brush, Fishing lines, Nets and building structures. At the present time very prospective directions of using nylon fiber is fiber-concrete and fiber-cement, reinforced with nylon fibers, using nylon fiber as post-tension or pretension reinforcing bars in reinforced concrete structures, applying polymeric and metalcomposites for structures. The main reason that nylon fiber is considered as construction material so rarely in India is non-availability and its high price on shipping, but the general trend of increasing product of nylon fiber and reducing its cost can said might change this situation in the constructionindustry. The effects of adding nylon fiber into the concrete matrix on compressive strength of cubes and split tensile strength of cylinders were evaluated in this work. Four test groups were constituted with the Nylon fiber percentages of 0.00%, 1%, 2% and 3%. The results showed the effect of Nylon fiber on concrete has a considerable amount of increase in compressive and split tensile characteristics; make a comparison of materials and about reasonability of applying nylon fiber in terms of operating conditions and economics.

S. Sharmila1 and Dr. G.S. Thirugnanam presented a paper on
"BEHAVIOR OF REINFORCED CONCRETE FLEXURAL MEMBER WITH HYBRID FIBRE UNDER CYCLIC LOADING". Concrete is the most widely used construction material because of its specialty of being cast

into any desired shape. The mainrequirements of Earthquake resistant structures are good ductility and energy absorption capacity. Fibre reinforced concrete possesses high flexural and tensile strength, improved ductility, high energy absorption to the conventional concrete against dynamic loads. Because of the advantages of FRC, it can be used in Earthquake resistant structures. When concrete is reinforced with random dispersed fibres which prevent micro cracks from widening. Addition of two fibres of different properties can improve the properties of fresh concrete. This paper deals with the flexural behavior of Hybrid Fibre Reinforced Concrete beams (Namely RCC, SFRC, HFRC1, 6 HFRC2) cast with Steel,Glass and Recron-3s fibres under cyclic loading. The various parameters such as load carrying capacity, stiffness degradation, ductility characteristics and energy absorption capacity of FRC beams were compared with that of RC beam. The companion specimens were cast and tested to study strength properties and then the results were compared. In general, it is concluded that the effect of adding hybrid fibres influence the behavior of beams by increasing the ductility characteristics by 80% and energy absorption characteristics by more than 160%. Instead of adding single fibre, the combination of different types of fibres(Hybrid fibres) increases the energy absorption capacity substantially. This phenomenon is particularly advantageous in caseof structures located in Earth quake prone areas.

Shelorkar Ajay , Malode Abhishek and Loya Abhishek presented a paper on ”EXPERIMENTAL INVESTIGATION ON STEEL FIBRE REINFORCEDCONCRETE USING METAKAOLIN” .The necessity of metakaolin in steel fibre reinforced concrete to enhance the strength properties of concrete. In the present day construction industry needs of finding effective materials for increasing the strength of concrete structures. Hence an attempt has been made in the present experimental investigations to study the effect of addition of steel Fibre at a dosage of 1.5% of the total weight of concrete as fibres. Metakaolin was used at 8% of the total weight of cement as metakaolin, and the addition of steel fibres at 1.5% and 8% of metakaolin.Experimental investigation was done using M40 mix and tests were carried out as per recommended procedures by relevant codes. The results were compared with control concrete it was observed that concrete blocks incorporated with steel fibre increased its compressive strength by 8.91% and tensile strength by 26.94%. Metakaolin and steel fiber blocks exhibited an increase in flexural strength of concrete in 58.28%.

3.MATERIAL AND ITS PROPERITIES

A. Cement

Ordinary Portland Cement (OPC) is by far the most important type of cement OPC 53 grade cement is mostly used for concrete production due to its higher strength. The Cement used has been tested for various proportions as per IS 4031-1988 and found to be confirming to various specifications of are 12269-1987.The specific gravity was 3.122.

B. Fine Aggregate

The aggregate size is lesser than 4.75 mm is considered as fine aggregate. It was stored in open space free from dust and water. River sand of 2.36 mm size sieve passed was used as fine aggregate. The specific gravity of 2.566 and fineness modulus 3.6 was used in the investigation.

C. Coarse Aggregate

The aggregate size bigger than 4.75 mm, is considered as coarse aggregate. Coarse aggregate passing through 20 mm sieve and retained in 12.5 mm sieve is collected for concrete work. Crushed angular granite metal of 6 to 12.5 mm size from a local source was used as coarse aggregate. The specific gravity of 2.743 and fineness modulus 4.7 was used.

D. Steel Fiber

Steel fibers are used concretes are given higher flexural, tensile and compression strength when compare to conventional concrete. Steel fibers are generally used to enhance the tensile strength and ductility of concrete. The primary function of steel fibers is to modify micro and macro cracking. By intercepting cracks at their origin, the steel fibers inhibit crack growth. In this project work **steel fibers** is used because bonding ability is higher than other types of steel fibre and it has a length 50mm and diameter 10mm. Aspect ratio of steel fiber is 50. Steel fibers are distributed uniformly throughout the concrete matrix. The primary function of steel fibers is to modify micro and macro cracking. By intercepting cracks at their origin, the steel fibers inhibit crack growth. For this reason, SFRC can be used to replace welded wire reinforcement or rebar which is used to control temperature or shrinkage cracks. The steel fibre sample shown in figure

Fig.1 steel fiber

E. Nylon Fiber

Nylon fibers are used in many applications, including clothes fabrics, bridal veils, package paper, carpets, musical strings, pipes, tents, and rope. Further, these two types of fibers can complement each other and further improve the engineering properties of concrete.

In this project work **nylon 6** fiber is used and it has a length 18mm and diameter 10 micron. The properties of nylon fibre is shown below .Tenacity-elongation at break ranges from 8.8g/d-18% to 4.3 g/d-45%. Its tensile strength is higher than that of wool, silk, rayon, or cotton.

- 100% elastic under 8% of extension
- Specific gravity of 1.14
- Melting point of 263oC
- Extremely chemically stable
- No mildew or bacterial effects
- 4 - 4.5% of moisture regain
- Degraded by light as natural fibers
- Permanent set by heat and steam
- Abrasion resistant
- Easy to wash

Fine and highly flexible (nylon) fibers can control the dry shrinkage and micro-cracks, while the thick and highly stiff (steel) fibers are able to sustain the macro-cracks resulting from high stress. Further, these two types of fibers can complement each other and further improve the engineering properties of concrete. The nylon 6 fibre sample is as shown in Figure 2.

Fig.2 Nylon fiber

F. Water

Portable water from tape is used for concrete casting and curing process as per IS456:2000 specifications. Good water is essential for quality concrete.

G. Reinforcement

Steel is an alloy of iron and carbon. Apart from carbon by adding small percentage of manganese, sulphur, phosphorus, chrome nickel and copper special properties can be imparted to iron and variety of steels can be produced. Fe415 grade steel rods are used during the casting of beams. The diameter of main rod 10mm. Stirrups used in beams is 8mm in diameter. The reinforcement is as shown in Figure 3.

Fig 3 Reinforcement details

I.Different Proportion of Fibres Used

Mix Grade	Fiber	Fiber %by volume	Fiber	Fiber % by volume
M 30	CC	0	CC	0
	Steel	1%	Nylon	1%
	Steel	1%	Nylon	2%
	Steel	1%	Nylon	3%

J.Mix Design

Concrete for M25 grade and M30 grade Were prepared as per IS.10262:2009 with w/c 0.45 and 0.50.Mix proportion for M25 grade and M30 grade concrete for material was as follows

TABLE 1. QUANTITIES OF MATERIALS

M30	
Material	Quantity
Cement	395Kg/m³
Fine Aggregate	864Kg/m³
Coarse Aggregate	1132K/gm³
Water	150.1K/gm³
W/c ratio	0.38

4.Test Methods

Testing of hardened concrete plays an important role in controlling and confirming the quality of concrete works. Systematic testing hardened concrete is inseparable part of any quality control programmed for concrete, which helps to achieve higher efficiency of material used and greater assurance of the performance of the concrete with regard to both strength and durability.

The test methods should be simple, direct, and convenient to apply.

- Compression test
- Flexural test
- Durability test

4.1Compression test

Compression test is the most common test conducted on hardened concrete, partly because it is an easy to perform, and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. The compression test is carried out on specimen's cubical specimens.

Cubes 150 mm × 150 mm × 150 mm in size were used. The cube moulds were cleaned thoroughly and properly oiled along their faces. The mould was then filled with concrete in three layers and compacted using a tamping rod. Further, the moulds were placed on the vibrating table for 60 seconds to achieve proper compaction and subsequently maintained on a plane and level surface in the laboratory for 24 hours. The cubes were demoulded and set aside for curing.

The compressive strength was calculated as follows:

$$\text{Compressivestrength (MPa)} = \frac{\text{Failure load}}{\text{cross sectional area}}$$

Table.2 Compression test for 7 days with various Nylon fibre %:

Mix	7 days	
	Failure load kN	Compression strength N/mm²
CC	585	26
S1%,N1%	595	26.44
S1%,N2%	610	27.11
S1%,N3%	720	32

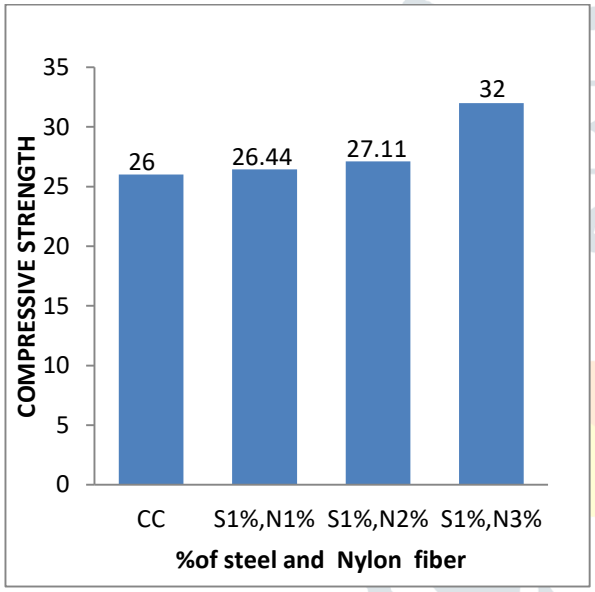
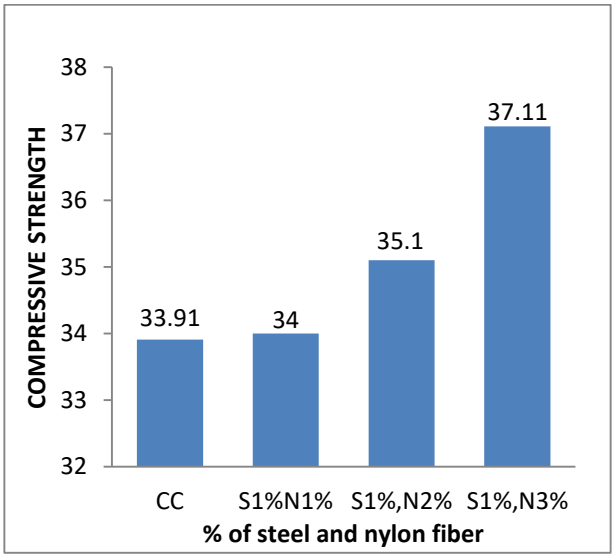
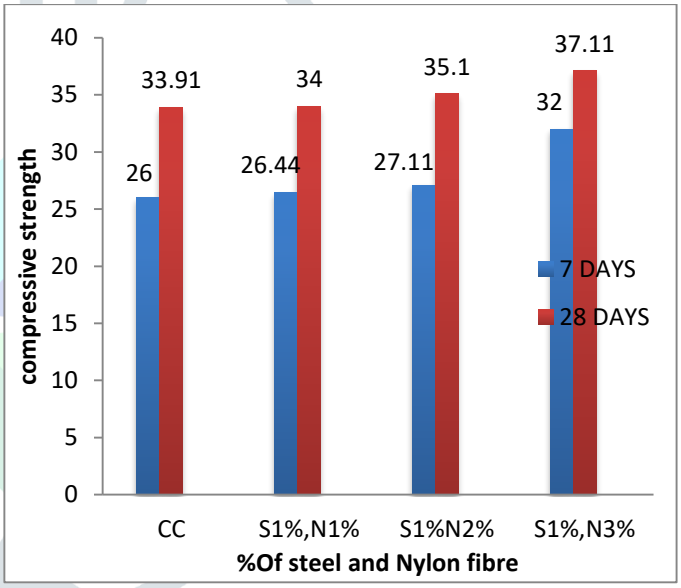


Table.3 Compression test for 28 days with various Nylon fibre %:

MIX	Failure load kN	Compression strength N/mm²
CC	763	33.91
S1%,N1%	765	34
S1%,N2%	790	35.1
S1%,N3%	835	37.11



Comparison of Compressive Test for 7 Days And 28 Days



4.2 Flexural Strength Test

Flexural strength test is carried by using beam specimen. Beam had 1600mm length, 150mm wide and depth 220mm. The beam moulds were cleaned thoroughly and properly oiled along their faces. The steel rods with stirrups placed in the mould before concrete placed in mould. The mould was then filled with concrete in three layers and compacted using a tamping rod. The beams were demoulded and set aside for curing.The cured specimens were tested under load frame instrument. The beam specimens were tested for midpoint loading and their deflection were observed with LVDT attached to the specimen. The readings were recorded in data logger attached to the loading

frame instrument. Gradual loading has been imposed on the specimen through a load cell 100tons capacity until failure. Beam is tested and the ultimate load carrying capacity of beam is finding out by using test results. The variation between load and deformation is plotted as a graph.

Fig.4 Beam details

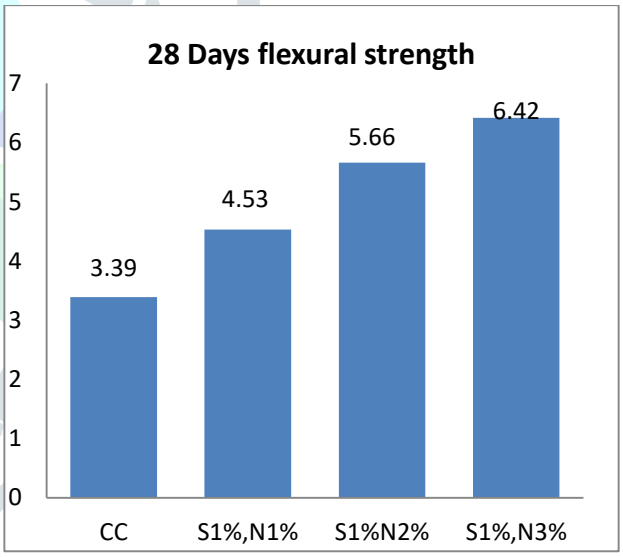
Table.4 Quantity of materials for various beams:

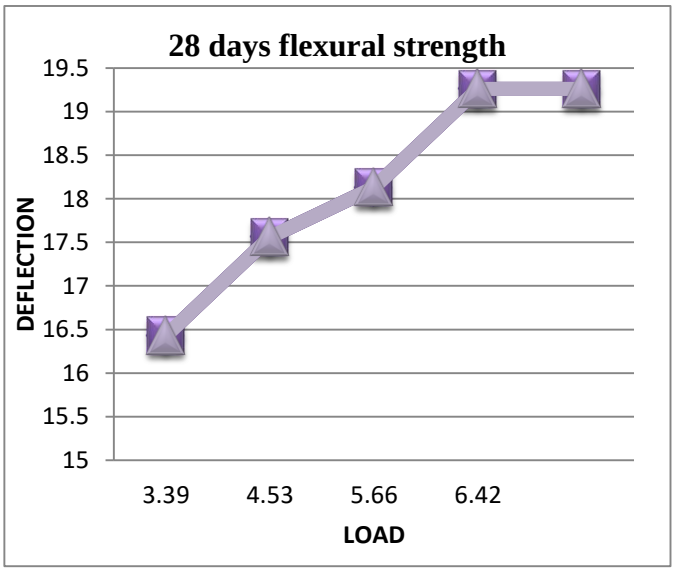
Mix	**CA Kg**	**FA kg**	**Cement kg**	**Steel Fiber kg**	**Nylon fiber kg**
Cc	22.24	50.171	65.73	-	-
S1% N1%	22.24	50.171	65.73	0.229	0.229
S1% N2%	22.24	50.171	65.73	0.229	0.458
S1% N3%	22.24	50.171	65.73	0.229	0.688

Fig.5 reinforcemnt placed in mould

Mix	Ultimate load(kg)	Ultimate Deflection(kg)
Cc	58	8.50
S1%,N1%	62	10.58
S1%,N2%	64	12.52
S1%,N3%	68	14.21

Mix	Flexural strength initial(N/mm²)	Flexural strength ultimate (N/mm²)
cc	3.39	16.43
S1%,N1%	4.53	17.56
S1%,N2%	5.66	18.13
S1%,N3%	6.42	19.26





4.3 Durability tests

The following are thevarious durability test carried out in this experimental study.

1. Acid Resistance Test

4.3.1 Acid attack Test

Cubes of size 150mm x 150mm x 150mm are cast for each mix. After 28 days of curing, all specimens were kept in atmosphere for 1day for constant weight. The weight of cubes were taken and then the cubes were immersed in 5% concentrated H_2SO_4 for 28 days. The acid solution was replaced whenever the pH value exceeds 9.5. After the completion of age of immersing in acid solution, the specimens were taken out and were washed in running water and kept in atmosphere for 1day for constant weight. Subsequently the specimens are weighed and loss in weight and hence the percentage loss of weight was calculated. The degree of acid attack was evaluated by compressive strength were conducted at 28 days.

Table.5 Acid Attack (H_2SO_4) in concrete

SI. No	Nylon fiber (%)	Steel fiber (%)	H2SO4			Loss in Compressive strength N/mm^2
			Initial Weight	Final Weight	Weight Loss (%)	
1	0	0	3.508	3.417	4.7	18.67
2	1	1	3.514	3.428	4.54	18.02
3	2		3.523	3.44	4.4	17.74
4	3		3.54	3.46	4.2	16.92

Fig .6 Durability test for cubes

5. CONCLUSIONS

- There is improvement in Compressive strength and flexural strength of Fibre Reinforced Concrete to Conventional Concrete because of addition of fibres. Flexural strength may be maximum for steel fibre 0.75 % when compares to conventional concrete. The maximum increase in compressive strength and flexural strength observed at having steel fibre ratio 1% in constant with nylon fibre addition in percentage of 1%, 2%,=.The optimum compressive strength increased at 2%.

- From this we can conclude that there is an increment in the nylon fibre content of 2% there is also an increment in flexural strength and compressive strength when compared to the conventional concrete.

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