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EXPERIMENTAL EVALUATION OF STEEL AND POLYPROPYLENE FIBRE CONCRETE WITH NORMAL CONCRETE

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Abstract: ***Many researches have been currently going to modify and improved the concrete properties by the addition of different types of materials. This paper represents the Optimum use of the fibres with the normal concrete mixture and will also help in achieving the desired results. This research work explores the effect of fibers i.e. steel and polypropylene with normal concrete. For this purpose, 120 specimens tested for each investigation of their physical properties like compressive strength, flexural strength and split tensile strength respectively. During olden days, only plain concrete were used and after that reinforced of steel concrete was introduced. In this work, the effects of steel and polypropylene fibers were observed after 28 days of casting. For this purpose, we kept the main focus on aspect ratios of fibers, orientation of fibers as well as quantities of fibers. The experimental results show that the hybridization of fibers has slight effect on compressive strength values, while it causes increase in modulus of rupture (flexural strength), toughness (compressive strength) and impact resistance (tensile strength) values. The concrete with fibers reinforcement increased the strengths any all cases. At Some places the polypropylene fibers and somewhere steel fibers. But after observing by T-test techniques and statistical data, it is also showing the all values are beneficial for the grade M40 mix with fibers.***

Keywords: steel Fibres, polypropylene Fibres, Compressive Strength, Flexural Strength and Split Tensile Strength.

I. INTRODUCTION

One of the most consumed man-made materials in construction field is concrete. It is the combination of cementitious materials, water, aggregates and also different types of admixtures in a particular ratio. Fresh concrete has a property of plasticity, which means before casting it behaves like plastic but as time goes, it gets hard like rock. These hardening properties happens due to chemical reactions between cement and water, it gets stronger with long time period. Since last century, the concrete structures durability was based on ordinary Portland cement, round steel bars of mild steel, which was easily available in market. As time spent, these materials also changed with their physical appearance, properties and strength. For example, Pozzolana cement is used in place of Ordinary cement and TMT bars are in use in place of mild steel bars. Polypropylene fiber reinforced concrete has also a great use in thin shell domes; repair of surfaces and as a component in overlaying systems. Polypropylene fiber reinforced concrete is significantly in use over last two decades. Polypropylene fibers are unable to provide the primary reinforcement in a concrete work because of low modulus and strength when compared to steel fibers. These are also used to provide a support to make a desired material behavior such as decrease in plastic behavior, shrinkage and improved toughness. Polypropylene fibers have been used maximum in structural applications since 1950 and more recently in pavement formation of roads. The availability of polypropylene is in two forms that are monofilament fibers and film fibers.

Production of monofilament fibers possible by an extrusion process through the orifices in a spinner jet and then cut them in desired length. This film may be stretchable into tapes axially. These tapes are stretched over carefully over design roller pin systems which generates longitudinal cutting and these can be cut or twisted to form various types of fibrillated fibers. The fibrillated fibers have a net-like structure.

The tensile strength of fibers can be developed by the molecular orientation obtained during extrusion process. Polypropylene has a melting point of 165oC and can resist the temperatures up to 100oC for short time period before softening. This is chemically inert material and any chemical that can damage to polypropylene fibers, will be much more harmful to concrete mix. The polypropylene fibers are capable to resist the degradation by ultraviolet radiations or oxygen. However, in concrete after mixing with fibers, these remedies can be eliminated. That's why the addition of fiber with concrete improved the concrete properties such as workability, brittleness, strength, corrosion resistance and ultimately increased life of the structure. Reinforcing capacity and proper functioning of fiber is based on length of fiber, diameter of fiber, the percentage of fiber and condition of mixing, orientation of fibers and aspect ratio. Aspect ratio is ratio of length of fiber to its diameter which plays an important role in the process of reinforcement.

II. LITERATURE REVIEW

As we know the properties of concrete gets improved due to the incorporation of fibre. Large no. of papers have being published which tells about the compressive strength, flexural strength and split tensile strength of concrete according to their opinion.

Bentur & Mindess [1], fibers are in use as reinforcement for quite some time now. Asbestos was first material widely used in the beginning of the 20th century. Manmade fibers produced from steel, glass, synthetics, asbestos and natural fibers such as cellulose, sisal and jute with high compressive

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strength.

J. Turmo, N. Banthia R. Gettu and B. Barragan [2] studied that incorporation of fibers to the mixes increases the material toughness both tension or compression, as indicated by the toughness indexes of the JSCE and ASTM standards Rashid Hameed et al. [3] made conclusions that On the basis of three-point bending tests performed on notched prismatic specimens constructed with mono- and hybrid fiber-reinforced concretes containing different fibers used in this study

Md Azree Othuman Mydin [4] summarizes three main properties of steel fiber reinforced high strength concrete which are mechanical, workability and durability properties. The investigation on the introduction of effect of steel fibers could be still promising as steel fiber reinforced concrete is used for sustainable and long-lasting concrete structures

S. O. Santos, J. P. C. Rodrigues, R. Toledo, R. V. Velasco [5] told that the effect of high temperatures on fiber reinforced concrete. It could be concluded that the inclusion of Polypropylene fibers in the concrete compositions prevented spalling.

G. Velayutham and C.B. Cheah [6] concluded It has been found that steel fiber high strength concrete (SFHSC) is not suitable for hygro-thermal curing compared to normal strength concrete.

Khaled Abdelrahman and Raafat El-Hacha [7] told about cost and ductility effectiveness of concrete columns strengthened with CFRP and SFRP Sheets. A cost and ductility effectiveness study was conducted on concrete columns wrapped with CFRP and SFRP sheets experimentally tested under uni-axial compression loading.

III. MATERIAL USED

CEMENT: Ordinary Portland cement of 43 grade has been used in this experimental work. OPC 43 grade of ULTRATECH cement has been used after investigate the strength of cement at 28 days.

FINE AGGREGATES: Locally available river sand passed through 4.75mm IS sieve has been used in the preparation of SFRC. It confirms to IS 383-1970 which comes under Zone I
COARSE AGGREGATES: The Coarse aggregate are obtained from a local quarry has been used. The coarse aggregate with a maximum size 20mm having a specific gravity 2.89.

FIBER MATERIALS:- According to terminology adopted by the American Concrete Institute (ACI) Committee 544, Fiber Reinforced Concrete, there are four categories of FRC based on fiber material type. These are Steel Fiber Reinforced Concrete, Glass Fiber Reinforced Concrete, Synthetic Fiber Reinforced Concrete, including carbon fibers; and Natural Fiber Reinforced Concrete. Different type of properties of different type of fibres are shown in Table No. 1.

Table No. 1 Properties of Fibers

Fiber	Diameter (μm)	Specific gravity	Modulus of elasticity (GPa)	Tensile strength (GPa)	Elongation at break (%)
Steel	5-500	7.84	200	0.5-2.0	0.5-3.5
Glass	9-15	2.60	70-80	2-4	2-3.5
Polypropylene:					
Aramid (Kevlar)	10	1.45	65-133	3.6	2.1-4.0
Carbon (high strength)	9	1.90	230	2.6	1.0
Cellulose	-	1.2	10	0.3-0.5	-
Acrylic	18	1.18	14-19.5	0.4-1.0	3
Polyethylene	-	0.95	0.3	0.7×10-3	10

ADMIXTURE:-According to ASTM C494, super plasticizer is an effective type of water-reducing admixture which improves the concrete workability. In present research, the admixture used was CICO which affects the cement particle separation leading to improvements in the concrete workability.

WATER: - Water used for mixing and curing was clean and free from injurious amounts of oils, acids, alkalis, salts and sugar, organic substances that may be deleterious to concrete. As per IS 456- 2000 Potable water is generally considered satisfactory for mixing and curing of concrete. Accordingly, potable tap water was used for the preparation of all concrete specimens.

IV. EXPERIMENTAL PROGRAMME

In this section, Normal concrete with steel and polypropylene fibers based specimens has been tested for the compressive strength, flexural strength and split tensile strength.

COMPRESSIVE STRENGTH TEST: To examine the compressive strength of Normal concrete with steel and polypropylene fibers, cube of 150mm×150mm×150mm has been used in this experimental work 30-40 cubes has been casted to determine the compressive strength. firstly cement and sand are mixed uniformly in dry condition . Secondly coarse aggregates are added in this mixture. Now steel and polypropylene fibers also added according to mix proportion to get the resultant mixture of M40 grade. Required dosage of water was added in the course of mixing. The cube moulds were demoulded after 24 hours then they were placed in water tank containing portable water and were left for curing. After that the specimen are tested at 28 days at compression testing machine (CTM) as per IS 516-1959. Compressive strength of concrete mixtures was measured at the age of 28 days and shown in Table No.2 and 3. There was an increase in compressive strength of cube concrete specimens produced with polypropylene fibers.

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Fig. 1 CUBE UNDER COMPRESSION TESTING MACHINE (CTM)

Table No. 2: Compressive Strength for Steel Fiber Mix

Compressive strength(N/mm²) of 1%, 2% and 3% Steel Fiber Grade M40							
Aspect Ratio		1%	Avg.	2%	Avg.	3%	Avg.
50	Sample CS1.1	51.2	52.74	53.1	54.34	55.6	55.66
	Sample CS1.2	53.2		54.8		55	
	Sample CS1.3	54.1		54		54	
	Sample CS1.4	54.4		55		57.5	
	Sample CS1.5	50.8		54.8		56.2	
60	Sample CS2.1	53.3	53.4	54.8	56.94	56	58.12
	Sample CS2.2	52.1		54.5		55.8	
	Sample CS2.3	54.4		58		58	
	Sample CS2.4	55.1		58		60.2	
	Sample CS2.5	52.1		59.4		60.6	

Table No. 3: Compressive Strength for Polypropylene fiber Mix

Compressive strength(N/mm²) of 1%, 2% and 3% Polypropylene Fiber Grade M40							
Aspect Ratio		1%	Avg.	2%	Avg.	3%	Avg.
50	Sample CP1.1	38.8	41.32	48.8	47.02	49.4	49.2
	Sample CP1.2	40.4		44.4		50.8	
	Sample CP1.3	41.5		49.5		43.5	
	Sample CP1.4	42.4		44		57.8	
	Sample CP1.5	43.5		48.4		44.5	
60	Sample CP2.1	40.5	45.28	44.8	50.98	49.4	54.48
	Sample CP2.2	45.5		50.4		45.4	
	Sample CP2.3	48.9		53.6		60.1	
	Sample CP2.4	43.5		52.2		55.4	
	Sample CP2.5	48		53.9		62.1	

FLEXURAL STRENGTH TEST:- To examine the flexural strength of Normal concrete with steel and polypropylene fibers, beam of size 150mm×150mm×70mm has been used in this experimental work. 30-40 beams has been casted to determine the flexural strength. The beams specimens of different proportions were demoulded after 24 hours and transferred to the curing tank for 28 days . After that, beams were placed to the two point loading machine on which we apply the load manually. Note down the load value at which cracks starts developing on the beam. Table no. 4 & 5 shows the values of flexural strength of Normal concrete with steel and polypropylene fiber beams at different mix proportions.

Fig. 2 TEST SET UP FOR BEAM

Table No. 4: Flexural Strength for Steel fiber Mix

Flexural strength(N/mm²) of 1%, 2% and 3% Steel Fiber Grade M40							
Aspect Ratio		1%	Avg.	2%	Avg.	3%	Avg.
50	Sample FS1.1	8.9	8.54	8.5	9.18	10.5	10.62
	Sample FS1.2	8.1		8.4		10.2	
	Sample FS1.3	9.1		9.4		11.2	
	Sample FS1.4	8.4		9.8		11.4	
	Sample FS1.5	8.2		9.8		9.8	
60	Sample FS2.1	8	8.58	8.9	9.622	11.5	11.54
	Sample FS2.2	8.2		9.5		9.4	
	Sample FS2.3	8.1		9.4		12	
	Sample FS2.4	9.2		10.2		12.4	
	Sample FS2.5	9.4		10.11		12.4	

Table No. 5: Flexural Strength for Polypropylene fiber Mix

Flexural strength(N/sqmm) of 1%, 2% and 3% Polypropylene Fiber Grade M40							
Aspect Ratio		1%	Avg.	2%	Avg.	3%	Avg.
50	Sample FP1.1	36.5	37.76	39.5	39.18	40.1	41.4
	Sample FP1.2	36.5		37.8		40.5	
	Sample FP1.3	40		38.4		42.7	
	Sample FP1.4	38.2		40		41.8	
	Sample FP1.5	37.6		40.2		41.9	
60	Sample FP2.1	40.5	40.14	39	42.18	32.8	44.26
	Sample FP2.2	42.5		45.5		34.9	
	Sample FP2.3	36.4		40		50.8	
	Sample FP2.4	40.2		43.2		51	
	Sample FP2.5	41.1		43.2		51.8	

SPLIT TENSILE STRENGTH TEST:- To examine the tensile strength of Normal concrete with steel and polypropylene fiber, cylinder of size 150mm×300mm has been used in this experimental work . 30-40 cylinders has been casted. The cylinder moulds were demoulded after 24 hours and transferred to curing tank for 28 days. After that cylinders were tested horizontally under compression testing machine (CTM). The results shows that in general, there is an increase in splitting tensile strength of cylinder concrete specimens with the addition of fibres to the concrete at 28 days age.

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Fig. 3 CYLINDER UNDER CTM

Table No. 6: Flexural Strength for Steel fiber Mix

Split Tensile strength(N/mm²) of 1%, 2% and 3% Steel Fiber Grade M40							
Aspect Ratio		**1%**	**Avg.**	**2%**	**Avg.**	**3%**	**Avg.**
50	Sample TS1.1	3.2	3.26	4.1	4.36	5.2	5.16
	Sample TS1.2	3		4.1		4.2	
	Sample TS1.3	2.9		4.3		5.4	
	Sample TS1.4	3.4		4.2		5.4	
	Sample TS1.5	3.8		5.1		5.6	
60	Sample TS2.1	2.9	3.36	6	4.76	4.5	5.28
	Sample TS2.2	3.2		3.5		5.6	
	Sample TS2.3	3.1		3.5		5.8	
	Sample TS2.4	3.4		5.2		5.9	
	Sample TS2.5	4.2		5.6		4.6	

Table No. 7: Flexural Strength for Polypropylene fiber Mix

Split Tensile strength(N/mm²) of 1%, 2% and 3% Polypropylene Fiber Grade M40							
Aspect Ratio		**1%**	**Avg.**	**2%**	**Avg.**	**3%**	**Avg.**
50	Sample TP1.1	4.2	4.16	4.5	5.3	5.1	5.76
	Sample TP1.2	2.4		4.5		5.1	
	Sample TP1.3	4.5		5.6		5.2	
	Sample TP1.4	4.5		5.8		6.2	
	Sample TP1.5	5.2		6.1		7.2	
60	Sample TP2.1	4.8	5.5	4.8	5.98	4.6	6.58
	Sample TP2.2	5.1		5.2		8	
	Sample TP2.3	5.6		6.2		6.1	
	Sample TP2.4	5.8		6.4		6.8	
	Sample TP2.5	6.2		7.3		7.4	

V. CONCLUSION

In this present study with the stipulated time and laboratory set up afford has been taken to enlighten the use of so called fiber reinforced concrete in accordance to their proficiency. It was concluded that:

- With the use of superplasticizer, it is possible to get a mix with low water to cement ratio to get the desired strength.
- In case of ordinary portland cement with the use of steel fiber, the 28 days compressive strength at 3% fiber content the result obtained is maximum.
- When polypropylene fiber mixed with nominal concrete, it shows compressive strength is less than steel i.e. 11%.
- After mixing of fibers (i.e. steel & polypropylene) with by 1%,2% and 3%, the compressive strengths increases gradually. Which means slightly changes comes by increasing the percentage fibers for both aspect ratios.
- As shown in graphs for aspect ratios i.e. 50 and 60, compressive strength changes maximum limit in aspect ratio 60. This shows if the length of fibers is more, then compressive strengths will be more.
- The flexural strength for aspect ratio 60 and polypropylene fibers is showing a long gap between steel and polypropylene fibers.
- If we compare the split tensile strength, for the aspect ratio 50, it is 10% variation between steel and polypropylene. Whereas for aspect ratio 50, it is approximately 20% variation in same.
- Polypropylene fibers will be more effective in tensile zone because they have property of plasticity.
- The null hypothesis in T-Test for compressive strength with aspect ratios 50 and 60 for steel and polypropylene fibers shows that values 0.0011 and 0.020 which is showing the results obtained by tests is correct.
- The value 0.0009 for split tensile strength is there in T-Test, it is more effective to show that samples taken for these test are accurate.
- The statistical technique i.e. T-Test for steel and polypropylene fiber of aspect ratio 50 and 60 in case of compressive strength are $1.23x10^{-6}$ and $8.64x10^{-5}$. The result came from these are showing that assumed hypothesis is null hypothesis and the result is best i.e. 95% true.
- The approximated characteristic strength values for sample in split tensile strength for steel and polypropylene and aspect ratio 50 and 60 is 0.000479 and $9.68x10^{-5}$. It gives the result assurance is more than 95%.

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