EXPERIMENTAL INVESTIGATION ON FIBRE REINFORCEMENT CONCRETE BY USING MACRO PLASTIC FIBRE

E. Ramya[1], L. Mary Rosary[2], M. Siva[3], T. Sathieshkumar[4]

[1,2,3]*PG scholars, M.E.,(Structural Engg.,) Dept of Civil Engineering, Gnanamani College of Engineering, Namakkal*
[4]*Assistant Professor, Dept. of Civil Engineering, Gnanamani College of Engineering, Namakkal, TamilNadu, India*

Abstract - *This paper presents an experimental study on concrete reinforced with fiber under axial loading condition. The cracks are the major cause of weakness in concrete particularly in large onsite applications leading to subsequent fracture and failure and general lack of durability. The weakness in tension can be overcome by the use of conventional rod reinforcement and to some extent by the inclusion of a sufficient volume of certain macro fibres. The strength and durability of concrete improve with the addition of fiber. An experimental program was carried out to explore its effects on compressive strength, split tensile, flexural strength and behavior. In fiber reinforced concrete, the macro plastic fiber delayed the development of macro cracks. The main aim of the investigation program is to study the effect of Polypropylene fiber mix by varying content such as 0%, 1.25%, 1.5%, 1.75%, & 2% with respect to the weight of concrete on the strength criteria of M30 and M40 and finding the optimum Polypropylene fibre content. The concrete specimens were tested at different age of 7 days, 14 days, 28 days level for mechanical properties of concrete and study the flexural behavior of the fiber reinforced concrete by using macro plastic fiber. Result show. The Strength of concrete can be increased by adding up to 1.75% of polypropylene to the concrete mix. The main benefit of using macro plastic fibres lies in improved ductility in the post-crack region and flexural toughness of concrete.*

***Key Words*: Fiber reinforced concrete, Beam, Macro plastic fiber, polypropylene fibre, compressive strength, flexural strength, split tensile strength, shrinkage**

1. INTRODUCTION

Concrete is widely used in structural engineering with its high compressive strength, low cost, and abundant raw material. Concrete has some shortcomings, for example, low tensile and flexural strength, poor toughness, high brittleness, and soon that restrict its application. To improve its tensile strength, reinforcing steel is often used in the concrete. Apart from traditional steel reinforcement, various fibres are also used to improve the properties of concrete, mainly for enhancing the tensile strength.

Plastic fibres are synthetic fibres, which can be in the form of microplastic fibres or macro plastic fibres. The microplastic fibres refer to the plastic fibres whose diameter ranges from 5 to 100 mm and length is 5– 30mm. These micro fibres can effectively control plastic shrinkage cracking, which is caused by shrinkage of fresh concrete during the first 24 hours after placement due to excessive evaporation of bleed water. It also significantly improves tensile strength and toughness of concrete. The macro plastic fibers normally have a length of 30–60 mm and a cross-section of 0.6–1mm. The macro plastic fibers are not only used to control plastic shrinkage but also mostly used for controlling drying shrinkage. A steel reinforcing mesh used to prevent the drying shrinkage cracks, but now it is gradually being replaced by the macro plastic fibres because of ease of construction, reduction in lower cost.

Fig 1.1 Polypropylene Fibre

Polypropylene is an economical material that offers a combination of outstanding physical, mechanical, thermal and electrical properties not found in any other synthetic fibres. There are two general types of fibres currently available in the market. These are referred to as fibrillated and monofilament.

1.1 Literature Review

Fiber reinforced concrete was successfully used in variety of engineering applications, because of its satisfactory and outstanding performance in the industry and construction field. However, most of the engineers and researchers have thought that how and why the fibers perform so successfully. So, to recognize the usage of fibers in concrete, in these last four decades, most of the research was done on mechanical behavior of fiber reinforced concrete and the fibers itself.

A study on the alkali resistance and performance of recycled polypropylene (PP) fibres in the 25 MPa and 40 MPa concretes, used for footpaths and precast panels, respectively was found in [1]. Shi Yin, Rabin Tuladhar [2], critically reviews the current state of knowledge and technology of using macro plastic fibres to reinforce concrete and its cost and environmental benefits and application of plastic fibres reinforced concrete. E. Mollaahmadi et.al [3] explored the effect of polypropylene fibers of different lengths and diameters on the flexural strength of the concrete. Shin Hwang et.al [4] improved the properties of polypropylene fibres in normal strength concrete and it was measured by using a drop-weight test and analyzed by using statistical procedures. A.M. Alhozaimy et.al [5] generated a comprehensive set of experimental data regarding the effects of collated fibrillated polypropylene fibers at relatively low volume fractions (below 0.3%) on the compressive, flexural and impact properties of concrete materials with different binder compositions.

Rana A. Mtasher et.al [6], studied the effects of polypropylene fiber on the compressive and flexural strength of normal weight concrete. The test results showed that the increase of mechanical properties (compressive and flexural strength) resulting from added of polypropylene fiber was relatively high. The increase was about 64 percent for compressive strength, while, in flexural strength was about 55.5 percent. Okan Karahan et.al [7], Reports of a comprehensive study on the durability properties of concrete containing polypropylene fiber and fly ash. Properties studied include unit weight and workability of fresh concrete, and compressive strength, modulus of elasticity, porosity, water absorption, absorptive coefficient, drying shrinkage and freeze–thaw resistance of hardened concrete.

2. METHODOLOGY

As in the literature review I have chosen the Macro plastic polypropylene fibre for making the concrete mix and I have selected the different proportions of polypropylene fibre for obtaining the strength variation at 0%, 1.25%, 1.5%, 1.75%, & 2% and for making the Polypropylene Fibre Reinforced Concrete (PPFRC) we required different materials which are described below.

2.1 Cement

Cement is the most important constituent of concrete, it forms the binding medium for the discrete ingredients made out of naturally occurring raw materials. "Ordinary Portland cement" 53 Mega Pascal grade of cement is used for concrete. The properties of cement were determined as per the IS 4031:1968

2.2 Fine Aggregate

The material which is smaller than 4.75mm size is called fine aggregate. Natural sands are generally used as fine aggregate. Angular grained sand produces, good and strong concrete because it has good interlocking property, while round grained particle of sand do not afford such interlocking. The specific gravity and water absorption were found to be 2.63 and 2.5% respectively, with sieve analysis data and fineness modulus value of sand confirms to grading zone I as per IS:383-1970.

2.3 Coarse Aggregate

The material retained on 4.75mm sieve is termed as coarse Aggregate. Crushed stone and natural gravel are the common materials used as coarse aggregate for concrete. For coarse aggregate crushed 20mm, normal size graded aggregate was used. The grading of aggregate should be conformed to the requirement as per IS: 383-1970.

2.4 Water

The major factor controlling strength, everything else being equal, is the amount of water used per bag of cement.

2.5 Super Plasticizer

Super plasticizer can increase the workability of concrete mix and reduce the amount of water needed. Therefore, it enables the use of very low water-to-cement ratio. Further lowering of water-to-cement ratio can be achieved by adding other mineral admixtures. The super plasticizer used for this project is polycarboxylate ether.

Determining the relative amounts of materials is known as mix design. Thus it can be defined as the process of selecting suitable ingredients of concrete and determining their relative quantities for producing the concrete of desired properties strength, durability and consistency, as per IS 10262:2009 economically as possible. Mix design are done as per IS 10262:2009 for M30 and M40 Grade concrete and it is shown in table1.

Table -1: Mix Design

Mix design	Water (L)	Cement (kg)	Aggregates (Kg)		Super plasticizer (L)
			Fine	Coarse	
M30	160	380	711	1283	7.6
M40	153	400	885	1126	8

Mix ratio for M30 is 1:1.87:3.37:0.45
Mix ratio for M40 is 1:2.21:2.81:0.45

3. EXPERIMENTAL INVESTIGATION

Testing of concrete plays an important role in controlling and confirming the quality of cement concrete. Cube, Beam & Cylinder is tested for its strength characteristics. The following tests are conducted, Compression strength test, Split tensile strength test, Flexural strength test (Two point loading).

3.1 Compressive Strength Test

The following procedure is adopted to conduct the compressive strength test

- Size of the specimen is 150×150×150mm cubes determined by averaging perpendicular dimensions at least at two places.
- Place the specimen centrally on the compression testing machine and load is applied continuously and uniformly on the surface parallel to the direction of tamping.
- The load is increased until the specimen fails and record the maximum load carried by each specimen during the test.
- Compressive strength was calculated as follows

Compressive strength = P/A×1000

where,

P= Load in KN

A=Area of cube surface=150×150 mm^2

Table -2: Compressive Strength of M30

S.No	% Of replacement	Curing Days(M30)		
		7 Days (N/mm2)	14 Days (N/mm2)	28 Days (N/mm2)
1	0%	14.15	32.77	38.5
2	1.25%	14.75	34.02	39.75
3	1.50%	15.42	34.75	41.20
4	1.75%	16.42	35.88	42.57
5	2%	15.4	32.97	40.65

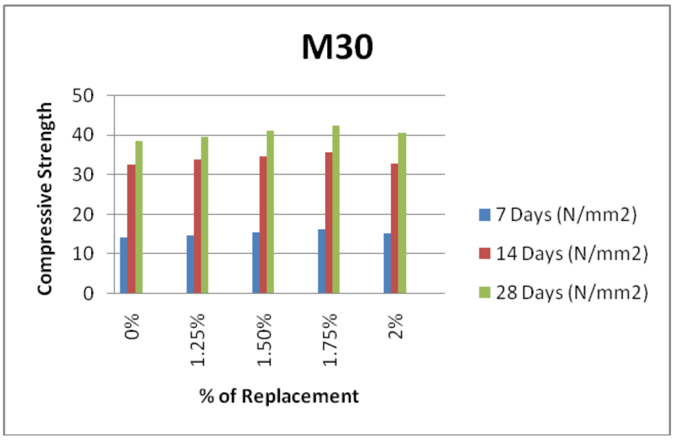

Chart -1: Compressive strength vs % of Polypropylene fibre added for M30

Table -3: Compressive Strength of M40

S.No	% Of replacement	Curing Days(M40)		
		7 Days (N/mm2)	14 Days (N/mm2)	28 Days (N/mm2)
1	0%	19.65	43.12	48.60
2	1.25%	20.50	44.62	49.85
3	1.50%	21.50	45.65	52.75
4	1.75%	22.50	46.95	54.00
5	2%	19.65	44.06	49.00

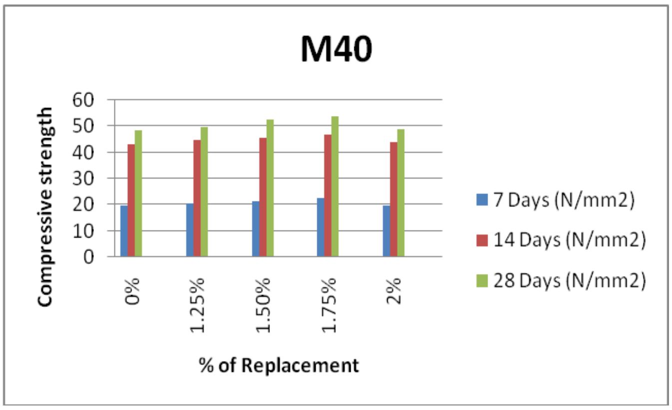

Chart -2: Compressive strength vs % of Polypropylene fibre added for M40

2.2 Split Tensile strength Test

The following procedure is adopted to conduct the tensile strength test.

- Draw diametrical lines on two ends of the specimen so that they are in the same axial plane. Diameter of specimen is 150mm and length 300mm.
- Determine the diameter of specimen to the nearest 0.2 mm by averaging the diameters of the specimen lying in the plane of pre marked lines measured near the ends and the middle of the specimen. The length of specimen also shall be taken be nearest 0.2 mm by averaging the two lengths measured in the plane containing pre marked lines.
- Centre one of the plywood strips along the centre of the lower pattern. Place the specimen on the plywood strip and align it so that the lines marked on the end of the specimen are vertical and cantered over the plywood strip. The second plywood strip is placed length wise on the cylinder cantered on the lines marked on the ends of the cylinder.

Apply the load without shock and increase it continuously at the rate to produce a split tensile stress of approximately1.4 to 2.1 N/mm2/min, until no greater load can be sustained. Record the maximum load applied to specimen .Computation of the split tensile strength was as follows.

Split tensile strength = 2P/πdL×1000
where,
P = Load in KN and π = 3.142
d = Diameter of cylinder = 150 mm
L = Length of cylinder = 300 mm

Table -4: Split Tensile strength of M30

S.No	% Of replacement	Curing Days(M30)		
		7 Days (N/mm^2)	14 Days (N/mm^2)	28 Days (N/mm^2)
1	0%	2.20	2.95	3.37
2	1.25%	2.36	3.15	3.65
3	1.50%	2.65	3.30	3.90
4	1.75%	2.82	3.64	4.12
5	2%	2.37	3.10	3.70

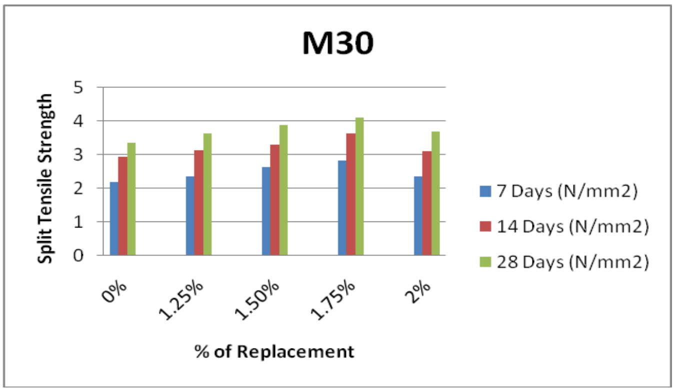

Chart -3: Split tensile strength vs % of Polypropylene fibre added for M30

Table -5: Split Tensile strength of M30

S.No	% Of replacement	Curing Days(M40)		
		7 Days (N/mm^2)	14 Days (N/mm^2)	28 Days (N/mm^2)
1	0%	3.00	3.65	4.20
2	1.25%	3.25	4.10	4.40
3	1.50%	3.40	4.25	4.55
4	1.75%	3.65	4.47	4.80
5	2%	3.10	4.00	4.37

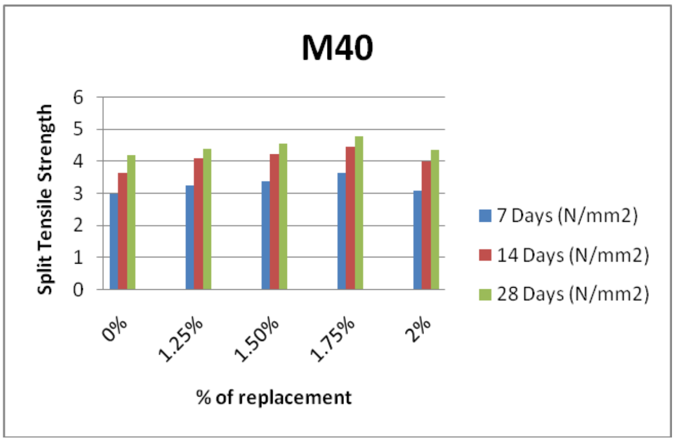

Chart -4: Split tensile strength vs % of Polypropylene fibre added for M40

2.3 Flexural Strength Test

The following procedure is adopted to conduct the flexural strength test.

- Brush the beam clean. Turn the beam on it side, with respect to its position as moulded, and place it in the breaking machine.
- Set the bearing plates with the beam and adjust for distance by means of the guide plates furnished with the machine.
- Place a strip if leather or similar material under the upper bearing plate to assist in distributing the load.
- Bring the plunger of the jack into contact with the ball on the bearing bar by turning the screw in the end of the plunger.
- After contact is made and when only firm finger pressure has been applied, adjust the needle on the dial gauge to "0".
- Here we are applying two point loading on the beam specimen, apply load till it breaks and note that as failure load .

Flexural Strength =PL/BD2×1000
Where,
P=Load in KN
L= Effective length of beam=250 mm
b=Width of the beam= 200 mm
d=Depth of beam =2000 mm

Table -6: Flexural Strength of M30

S.No	Load (KN)	Deflection On Beam M30				
		0%	1.25%	1.50%	1.75%	2%
1	0	0	0	0	0	0
2	5	2.30	2.20	2.0	1.90	2.40
3	10	4.00	4.50	4.20	4.00	4.75
4	15	7.70	7.50	7.20	7.00	8.00
5	20	11.5	10.85	10.6	10.0	11.25
6	25	13.12	12.9	12.5	11.8	13.40
7	30	12.20	13.40	12.8	11.9	13.50

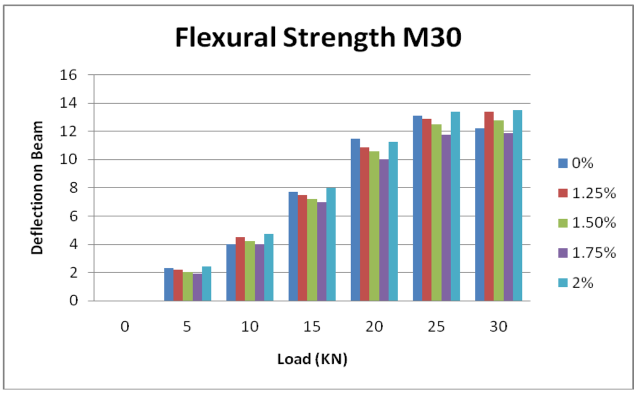

Chart -5: Variation in Flexural strength of M30 concrete

Table -7: Flexural Strength of M30

S.No	Load (KN)	Deflection On Beam M40				
		0%	1.25%	1.50 %	1.75 %	2%
1	0	0	0	0	0	0
2	5	2.1	1.95	1.75	1.30	2.20
3	10	4.20	4.00	3.90	3.50	4.40
4	15	7.50	7.40	7.20	6.50	7.80
5	20	10.85	10.65	10.0	9.20	11.00
6	25	12.95	12.80	12.2	12.0	13.0
7	30	13.12	13.00	12.9	12.4	13.8

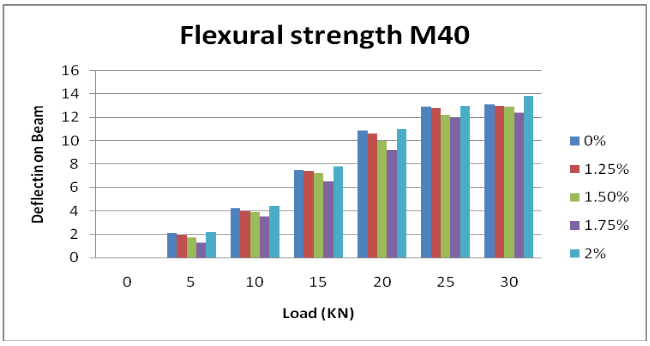

Chart -6: Variation in Flexural strength of M40 concrete

4. TEST RESULTS AND DISCUSSION

According to the above charts that are derived from the results we can conclude that up to 1.75% of polypropylene in concrete is suitable for preparing the specimen. By adding this fiber to the concrete we can increase the property of concrete. From the study, improvement in characteristic strength of concrete specimens with polypropylene fiber, the optimum mix percentage of polypropylene fiber that should be mixed for better strength results was arrived at 1.75%

From the testing on concrete cube with optimum polypropylene fiber mixing, it is found that the compressive strength of the concrete cube is found to increase by about 90%in M30 grade and also 90% in M40, when compared to ordinary concrete mix without polypropylene fiber. It is also noted from the test that, cracks developed at the cube surface is very litter. This shows that the crack formation is arrested by the polypropylene fiber to an extent.

From the testing on concrete cylinder with optimum polypropylene fiber mixing, it is found that the split tensile strength of the concrete cylinder is found to increase by about 91% in M30 and also 91% M40, when compared to ordinary concrete mix without polypropylene fiber. From the testing on plastic fiber reinforced concrete beam with optimum polypropylene fiber mixing, it is found that the flexural strength and the behavior of the beam is found to be increased by about 111%, for M30 and 105% for M40 .when compared to ordinary beam mix without polypropylene fiber.

5. CONCLUSION

Based on this experimental investigation the behavior of polypropylene mixed concrete was concluded below. Use of polypropylene fiber gives good cohesive, uniform and dense mix and diminishes the segregation and bleeding tendency. The Strength of concrete can be increased by adding up to 1.75% of polypropylene to the concrete mix. It also increases the bonding strength between the concrete materials. The strength of the concrete is increased by adding up to 1.75% of polypropylene. Tension cracks were formed on both control and macro plastic fiber reinforced concrete beams in middle span and shear cracks are formed near support region. The macro plastic fibres decrease workability of the fresh concrete, but effectively control plastic shrinkage cracking. The macro plastic fibers also have obvious effects on the compressive and flexural strength, which are dominated by the concrete matrix properties. The main benefit of using macro plastic fibres lies in improved ductility in the post-crack region and flexural toughness of concrete.

REFERENCES

[1] D. Yin, S., Tuladhar, R., Riella, J., Chung, D., Collister, T., Combe, M., & Sivakugan, N. Comparative evaluation of virgin and recycled polypropylene fibre reinforced concrete. Construction and building materials, 2016, pp. 134-141.

[2] Aly T Sanjayan G and Collins F (),"Effect of polypropylene fibres on shrinkage and cracking of concretes", Journal of Materials and Structures, Vol. 41, 2014,pp. 1471-1753.

[3] Arivalagan S, "Earthquake-Resistant Performance of Polypropylene Fiber Reinforced Concrete Beams", Journal of Engineering and Technology, Vol. 2 (01), 2014, pp. 63-67.

[4] Banthia N and Gupta R, "Hybrid fiber reinforced concrete (HYFRC):fiber synergy in high strength matrices", Journal of Materials and Structures, Vol.37, 2013, pp. 707-716.

[5] Bureau of Indian Standards, "Concrete Mix Proportioning Guidelines (10262-2009).

[6] Eswari S, Raghunath P and Suguna K, "Ductility Performance of Hybrid Fiber Reinforced Concrete", American Journal of Applied Sciences, Vol. 5 (9), 2012, pp. 1257-1262.

[7] Ratwani V, Ratwani M and Duggal S, A book of "Analysis of Structures", Laxmi Publication.

[8] Shah V and Karve S (2011), A book of "Limit state theory & design of reinforced concrete IS 456-2000, Structures Publications, Pune.

[9] Shetty M S (2011), "Concrete Technology Book", S. Chand and Company.

[10] Shukla M, "Behaviour of Reinforced Concrete Beams with Steel Fibers under Flexural Loading", International Journal of Earth Sciences and Engineering, Vol. 4, Oct. 2010, pp. 843-846