EFFECT ON MECHANICAL PROPERTIES OF CONCRETE USING NYLON FIBERS

Nitin [1], Dr. S.K. Verma[2]

[1] PG student, Dept. of Civil Engineering (Structures), PEC University of technology, Chandigarh, India.
[2]Associate Professor, Dept. of Civil Engineering (Structures), PEC University of technology, Chandigarh, India.

Abstract *This paper presents the results of an experimental study for enhancing compressive strength, split tensile strength and flexural strength of concrete using nylon fibers with volume fractions (V_f) of 0.5%, 1.0% and 1.5% were used. Cubes, cylinders and beams were casted with different volume fractions. The samples with added nylon fibers of 1% showed better results in compressive strength and split tensile strength, 1.5% for flexural strength.*

Key Words: Nylon fiber, Volume fraction, FRC.

1. INTRODUCTION

Concrete is the most commonly used construction material worldwide. Concrete is relatively strong in compression and weak in tension and tends to be brittle in behaviour. The weakness in tension can be overcome by providing steel bars and to some extent by the mixing of a sufficient volume of certain fibers. The fibers should not be used as primary reinforcement of concrete but only used as secondary reinforcement.

Several methods for strengthening of concrete have been developed. These incorporate addition of material to increase gross sectional area, post tensioning techniques, etc. In spite of the fact that these strategies can be practically used and effective sometimes, but sometimes uneconomical or insufficient to meet desired results.

1.1 Fiber Reinforced Concrete

Fiber-reinforced concrete (FRC) is concrete containing fibrous material which increases its structural reliability. It contains short discrete fibers that are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers– each of which lend varying properties to the concrete. In addition, the character of fiber-reinforced concrete changes with varying concretes, fiber materials, geometries, distribution, orientation, and densities. The concept of using fibers or as reinforcement is not new. Fibers have been used as reinforcement since ancient times. Historically, horse hair was used in mortar. In the 1900s, asbestos fibers were used in concrete. In the 1950s, the concept of composite materials came into being and fiber-reinforced concrete was one of the topics of interest. Once the health risks associated with asbestos were discovered, there was a need to find a replacement for the substance in concrete and other building materials. By the 1960s, steel, glass (GFRC), and synthetic fibers such as polypropylene fibers were used in concrete. Research into new fiber-reinforced concretes continues today. Effect of fibers in concrete are usually used in concrete to control cracking due to plastic shrinkage and to drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibers produce greater impact, abrasion, and shatter–resistance in concrete. 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" (V_f). V_f typically ranges from 0.1 to 3%. If the fiber's modulus of elasticity is higher than the matrix (concrete or mortar binder), they help to carry the load by increasing the tensile strength of the material. Increasing the aspect ratio of the fiber usually segments the flexural strength and toughness of the matrix. However, fibers that are too long tend to "ball" in the mix and create workability problems. Some recent research indicated that using fibers in concrete has limited effect on the impact resistance of the materials. This finding is very important since traditionally, people think that ductility increases when concrete is reinforced with fibers. The results also indicated that the use of micro fibers offers better impact resistance to that of longer fibers. Blends of steel and polymeric fibers are often used in construction projects in order to combine the benefits of both products; structural improvements provided by steel fibers and the resistance to explosive spalling and plastic shrinkage improvements provided by polymeric fibers.

FRC materials having a hardening behavior in tension. The use of fiber for strengthening of concrete is proposed here. The cubes were cast in steel moulds of inner dimensions of 150x 150 x 150mm, the cylinders with 150x 300mm height and the beams with 100x 100 x 500mm. The influence of different amount of nylon fibers content on concrete properties were investigated. Compression test, split tensile and flexure tests were performed on cube, cylinder and beams respectively.

1.2 Objective

The objective of present study to investigate the effect of addition of nylon fibers with different percentages on strength characteristics of concrete.

2. EXPERIMENTAL PROGRAM

Test program was planned to generate in below listed information:

- To obtain the Properties of constituent materials of concrete used in the investigation as per relevant Indian Standard codes.
- To design the reference concrete mix.
- To cast cubes, cylinders containing nylon fibers with different percentages with above designed mix to determine the effect of nylon fibers on the compressive and split tensile strength of concrete.

3. TEST MATERIALS

3.1 Cement

In the present investigation, Ordinary Portland cement (OPC) of 43 Grade (Shree Ultratech) from a single batch was used for all the concrete mixes. The grading of cement varies due to the presence of high quality limestone, modern equipment, better particle size distribution, finer grinding and better packing. Cement taken was fresh and without any lumps with uniformity in its color. The cement was tested as per IS: 8112- 1989 for its physical properties and compressive strength 7 and 28 days, the results of various tests conducted are reported in the table 3.1

Table 3.1-Properties of cement

S. N0.	Test/Property	Requirement as per IS 8112:1989	Observed Value
1	Normal Consistency	-	32%
2	Setting Time (in minutes) Initial Final	>60 <600	105 375
3	Specific Gravity	3.15	3.11
4	Fineness of Cement (By 90 micron sieve)	Not more than 10%	2%
5	Compressive Strength (MPa) 7 Days 28 Days	>33.0 >43.0	35.5 48.5

3.2 Fine aggregates

Natural sand is generally used as fine aggregate. But it may contain some impurities therefore before using it, sand should be washed thoroughly. Angular shaped particle produces strong concrete because it has better interlocking properties. In this study, locally procured sand conforming to grading zone II was used. The sand first was sieved through 10 mm sieve to remove any particles greater than 4.75mm and then was washed to remove the lumps of clay and other foreign material. Weight taken in sieve analysis was 1000gms. The physical properties of fine aggregate are measured in Table 3.2 and sieve analysis results are presented in Table 3.3.

Table 3.2- Physical Properties of fine aggregates

Property	Value
Specific Gravity	2.602
Water Absorption	1.8%

Table 3.3- Sieve analysis of fine aggregates

IS Sieve (mm)	Wt. Retained (gms)	Cumulative Wt. Retained	% Cumulative Wt. Retained	% Passing
10	-	-	-	100
4.75	-	-	-	100
2.36	119	119	11.9	88.1
1.18	375	494	49.4	50.6
0.600	139	633	63.3	36.7
0.300	128	761	76.1	23.9
0.150	119	880	88.0	12.0
0.075	49	929	92.9	7.1

3.3 Coarse aggregates

In the present work, locally available crushed stone aggregates passing through 20 mm IS sieve was used. Maximum size of aggregates used is 20mm. The aggregate were first sieved through 10 mm sieve and then through 4.75 mm sieve. They were then washed to remove dust and dirt and were dried to surface dry condition. The properties of aggregates were found to conform the requirements of IS: 383-1970. The sieve analysis and various properties of coarse aggregate are presented in Table 3.4, Table 3.5 and Table 3.6 respectively. Weight taken for sieve analysis was 5000gms.

Table 3.4- Physical properties of coarse aggregates

Property	Value
Specific Gravity	2.66
Water Absorption	2.5 %

Table 3.5- Sieve analysis for 20 mm aggregates

IS Sieve (mm)	Weight Retained (gms)	Cumulative Wt. Retained (gms)	% Cumulative Wt. Retained	% Passing
20	245	245	4.9	95.1
16	3355	3600	72	28
12.5	1207	4807	96.14	3.86
10	160	4967	99.34	0.66
4.75	16	4983	99.66	0.34

Table 3.6-Sieve analysis for 10 mm aggregates

IS Sieve (mm)	Weight Retained (gms)	Cumulative Wt. Retained (gms)	% Cumulative Wt. Retained	% Passing
12.5	17	17	0.34	99.66
10	2021	2038	40.76	59.24
4.75	2897	4935	98.70	1.30
2.36	33	4968	99.36	0.64
1.18	18	4986	99.72	0.28

3.4 Water

Water is an important constituent of concrete as it actively participates in chemical reaction with cement. Since it helps to form strength giving cement gel, the quantity as well as quality of water is required to be looked carefully. Water to be used for both mixing and curing of concrete should be free from injurious amounts of deleterious materials. As per IS: 456-2000 potable water is generally considered satisfactory for making and curing of concrete. In the present study, potable tap water was used for preparation of all concrete specimens.

3.5 Steel

High yield strength deformed (HYSD) 'TOR' steel bars of 12 mm and nominal diameter were used as tension reinforcement in beams, whereas 8 mm steel bars were used as top reinforcement; 8 mm diameter bars of mild steel were used as nominal shear reinforcement in the form of two – legged closed stirrups in all the specimens at a spacing of 160mm center to center. The reinforcing bars conformed to the requirements of IS: 1786-1985. The properties of steel used in this study are listed in table 3.7.

Table 3.7-Properties of steel

Properties	Main reinforcement	
	8mm dia bars	12mm dia bars
Elongation (%)	19.41	18.32
Yield strength	426.21 MPa	434.5 MPa
Ultimate strength	491.8 MPa	487.71 MPa

3.6 Mix Design

The mix design was done using IS: 10262–2009. By conducting trial mixes and making suitable adjustments in the mix proportion for good slump and requisite strength, the following mix proportion has finally been arrived at as shown in Table-3.8

Table-3.8 Mix proportion of mix design.

Water(liters)	cement(Kg)	Fine aggregate(Kg)	Coarse aggregate(Kg)
164.87	361.87	693.74	1207.75
0.45	1.00	1.92	3.3

Table 3.9- Various mix proportion of different trails**.**

Trial mix	w/c ratio	Water (liters)	Cement (kg)	Fine aggregates (kg)	Coarse aggregates (kg)
Mix 1	0.45	164.87	361.87	693.74	1207.75
Mix 2	0.43	160	370	675	1200
Mix 3	0.42	160	380	711	1283

4. RESULTS AND DISCUSSION

Compressive strength, Split tensile strength and flexural strength tests were carried out on concrete mixed with nylon fibers at different percentages of 0.5%, 1.0%, and 1.5% by making specimens of cubes, cylinders and beams respectively.

Table 4.1: Compressive strength of Reference mix

S.No	Grade of concrete	Trial mix	Load at failure (kgf)	Cube compressive strength (f_{ck}) (Mpa)	Average Compressive strength (MPa)
1	M30	Mix 1	810	36	35.9
			813	36.13	
			807	35.86	
2	M30	Mix 2	790	35.11	35.34
			808	35.91	
			788	35.02	
3	M30	Mix 3	870	38.66	38.6
			862	38.31	
			873	38.8	

From the test results of trial Mix 1, Mix 2 and Mix 3 suitable target mean strength which was closer to 38.25 MPa was arrived with trial Mix 3 at w/c ratio of 0.42. So trial Mix 3 with cement content 380Kg/m^3 was reference mix for study. Split tensile strength and flexure strength for reference mix are 3.32 MPa and 4.21 MPa respectively.

Table 4.1: Compressive strength of FRC with different volume fraction of nylon fiber

S.No.	Grade of concrete	Volume fraction (V_f)	Ultimate load at failure	Flexural strength (MPa)	Average flexural strength (MPa)
1	M30	0.50%	14.9	4.47	4.42
			14.5	4.36	
			14.7	4.43	
2	M30	1.00%	14.9	4.47	4.61
			16	4.82	
			15.1	4.54	
3	M30	1.50%	16.3	4.91	4.99
			16.5	4.94	
			17.1	5.12	

Table 4.2: Split tensile strength of FRC with different volume fraction of nylon fiber

S.No.	Grade Of concrete	Volume Fraction (Vf)	Ultimate load at failure (Kgf)	Split tensile strength (MPa)	Average split tensile strength (MPa)
1	M30	1.50%	241.6	3.42	3.68
			264.8	3.75	
			274.2	3.88	
2	M30	1.00%	288.9	4.09	4.16
			301.6	4.27	
			291.1	4.12	
3	M30	0.50%	262.8	3.72	3.81
			272.7	3.86	
			272.1	3.85	

Table 4.3: Flexural strength of FRC with different volume fraction of nylon fiber

S.No.	Grade of concrete	Volume fraction (V_f)	Ultimate load at failure (Kgf)	Flexural strength (MPa)	Average flexural strength (MPa)
1	M30	1.50%	866.2	38.5	38.86
			882	39.2	
			875.2	38.9	
2	M30	1.00%	945.6	42.03	42.77
			955.5	42.47	
			984.4	43.75	
3	M30	0.50%	892.2	39.66	39.2
			871.8	38.75	
			882.1	39.2	

It has also been proved by extensive research and field trials carried out on fibers, that addition of fibers to conventional plain or reinforced concrete imparts improvements to several properties of concrete, particularly those related to strength, performance and durability. The weak matrix in concrete, when reinforced with fibers, uniformly distributed across its entire mass, gets strengthened enormously. In matrix fibers are act as crack arrester due to this fibers increases the ductility of concrete and this increment effect on the mechanical properties of concrete and results are shown in above tables.

5. CONCLUSIONS

The following major conclusions can be drawn from the present study:

• From experimental results it can be concluded that with addition of 1.0% volume fraction of nylon fibers in M30 concrete there was an increment of the compressive strength upto 10% at 28 days strength.

• From experimental results it can be concluded that with addition of 1.0% volume fraction of nylon fibers in M30 concrete there was an increment of the split tensile strength upto 25% at 28 days strength.

• From experimental results it can be concluded that with addition of 1.5% volume fraction of nylon fibers in M30 concrete there was an increment of the flexural strength upto 18% at 28 days strength.

REFERENCES

[1] IS 456:200, 'Indian Standard Code of Practice for Plain and Reinforced Concrete', *Bureau of Indian Standards*, New Delhi.
[2] IS: 10262-1982, 'Recommended Guide Lines for Concrete Mix Design', *Bureau of Indian Standards*, New Delhi.
[3] IS: 383-1970, 'Indian Standard Specification for Coarse and Fine Aggregates from Natural Sources for Concrete', *Bureau of Indian Standards*, New Delhi.
[4] IS: 516-1959, 'Methods of Test for Strength of Concrete', *Bureau of Indian Standards*, New Delhi.
[5] IS: 8112-1989, 'Specification for 43 Grade Ordinary Portland Cement (First Revision with Amendment No.3)', *Bureau of Indian Standards*, New Delhi.
[6] Ramujee, K.; (2013), 'Strength properties of polypropylene fiber reinforced concrete', *International Journal of Innovative Research in Science, Engineering and Technology,* Vol 2, pages 3409-3413.
[7] Saxena, J., Saxena, A.; (2015), 'Enhancement the Strength of Conventional Concrete by using Nylon Fiber ', *International journal of engineering and science*, Vol 5(2), pages 56-59.
[8] Yakhlaf, M., Saifuddin, M., Soudki, K.A.; (2013), 'Properties of freshly mixed carbon fiber reinforced self consolidating concrete', *Construction and building materials*, Vol 46, page 224-231.