Original Article

ISSN: 2349 - 4891

International
Journal of Recent Research and Applied Studies
(Multidisciplinary Open Access Refereed e-Journal)

An Experimental Investigation on Nylon Fibre (Textile Waste) Reinforced Concrete

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Received 22nd December 2015, Accepted 15th January 2016

Abstract

Plain concrete possess very low tensile strength, limited ductility and little resistance to cracking. Internal micro cracks are inherently present in concrete and its poor tensile strength is due to the propagation of such micro cracks. Fibres, when added to a certain percentage in the concrete improve the strain properties as well as crack resistance, ductility, as flexure strength and toughness. The present paper outlines the experimental investigation conducts on the use of nylon fibre waste material of diameter 0.3mm and length of 45mm, having an aspect ratio of around 150 was employed in percentage 0.5 to 1.5 percentage by weight in concrete and property like compressive strength, flexural strength and tensile strength were studied and synthetic nylon waste to be disposed considerably.

Keywords: Nylon Fibres, fibre reinforced concrete, waste disposal.

Introduction

Concrete made with Portland cement has certain characteristics. It is relatively strong in compression but weak in tension and tends to be brittle[1-3]. The introduction of fibre was brought in as an alternative to developing concrete in view of enhancing its flexural and tensile strengths. Although the basic governing principles between conventional reinforcement and fibre systems are identical, there are several characteristic variations; such as - fibres are generally short, closely spaced and dispersed throughout a given cross section[2].The weakness in tension can be overcome by the use of a small fraction of nylon fibre in concrete.

In this study synthetic nylon fibres were obtained and used from the textile waste. There are two varieties of nylon which are highly used (i.e), nylon 6,6 and nylon 6. The nylon 6,6 is natural nylon and they are biodegradable, but nylon 6 is synthetic nylon and are non-biodegradable and it has numerous uses like to use in the production of yarn, fabric, tooth brushes and bristle brushes etc., Nylon is the truly synthetic fibre[5]. The global consumption of non-woven is about 49 thousand tons by 2000 and 56 thousand tons by 2005 and is increased very rapidly in recent years. Also protection of an environment from these pollution is one of the serious issues of this time. In addition to the known causes of environmental degradation such as pollution, coastal erosion, etc., the disposal of nylon waste is also a major problem.

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Synthetic fibre could be a better solution for enhanced performance, such as- facilitate light weight concrete structure, high corrosion resistance; better residual (post-cracking) flexural strength, smaller crack width and improved performance in impact, abrasion[6-8]. Utilizing the advantages of textile synthetic nylon fibres in concrete and as well as nylon waste to be disposed considerably. Therefore, our aim is to improve the property of concrete and also to reduce the harmful waste.

In this study, mechanical behaviour of concrete reinforced with three different percentages of textiles synthetic fibres where plain concrete as a control specimen was investigated. In pursuit of this investigation, several laboratory works were performed – for instance, casting and testing of – (i) cubes for compression and tension. (ii)Prisms for the determination of flexural strength and finally (iii) making comparison and discussion of the test results.

Experimental Program

1) Materials

The main component of the textile synthetic fibre used. This synthetic fibre's nominal Diameter and length were 0.3 and 45 mm and had an aspect ratio of 150 and a specific gravity of approximately 1.1. The average tensile strength of the fibre was 90 MPa with a modulus of elasticity of1320 MPa.

The specific gravity of fine aggregate =2.54
Water absorption of fine aggregate =2.25 %
The given sample of fine aggregate falls under Zone– II
Fineness modulus for fine aggregate value range from 2 to 4.
The specific gravity of coarse aggregate =2.60
Water absorption of Coarse aggregate =2.35 %
Fineness modulus for coarse aggregate value=7.8

The Slump observed for the given sample =150 mm
The Compaction Factor observed for the given sample =0.896

2) Mixing proportions

The concrete mix ratio was 1:1.22:2.8:0.43 (cement: fine aggregate: coarse aggregate: w/c ratio). Table1 shows the detail of mixes which were used in concrete casting.

Table I. Details of concrete mixes

Specimen ID	Fibre Volume Fractions	Cement	Fine Aggregate Kg/m^3	Coarse Aggregate Kg/m^3	Water
	(%)	Kg/m^3	Kg/m^3	Kg/m^3	Kg/m^3
M1	0%	425.8	518.4	1181.3	183.1
M2	0.5%				
M3	1.0%				
M4	1.5%				

Three types of moulds were used to cast the specimens. The moulds with dimensions of 100 mm × 100 mm ×500 mm were used for prisms, the moulds with dimensions of 100 mm × 100 mm × 300 mm were used for prisms and the moulds with the dimensions of 100mm × 100 mm × 100 mm were used for cubes. Where, the cubes were cast to determine the compressive and tensile strength, beams were cast to determine the shear strength and prisms were cast to determine the stress strain relationships of the textile synthetic fibre reinforced concrete.

Among the four batches, six cubes, three beams and three prisms were cast in each batch. A total of 0.10 m3 concrete mixes involving four batches was cast with four different quantities of textile synthetic fibres such as 0, 0.5, 1.0 and 1.5% of volume fractions respectively. The plain concrete specimen was used as a reference to compare with all other specimens. Mechanical behaviour of concrete, for instance, compressive, tensile and shear strength and stress-strain relationships were determined after a curing period of 7,14 & 28 days.

3) Mixing sequences

A mixer machine was used to get the standard quality of concrete. With the mixer machine, firstly, the coarse aggregate was added, followed by the textile synthetic fibres. These dry ingredients were mixed for about two minutes, so that the fibres were evenly distributed throughout the mix. Special care was taken so as to ensure no fibre balls were formed which would affect the concrete's consistency (e.g. Slump or flow). Then fine aggregate and cement were added into the mixture machine.

These dry ingredients were mixed for about one minute and then mixed with water. Concrete was placed in the moulds in two layers and a vibrator was used to compact properly. After finishing the vibrating of the top surface a trowel was used to make the top surface smooth. The specimens were stored for 24 hours under a temperature of 16^{0}C to 27^{0}C to set the concrete. After24 hrs the specimens were de-moulded and kept in the water tank for 28 days of curing and then the specimens were prepared for testing.

Results and Discussion

A. Compressive Strength test results

A total of 12 cubes of size 100×100×100 mm with four different percentages of textile synthetic fibre volume fractions, such as 0, 0.5, 1.0 and 1.5% and tested.

Figure 1. Instrumentation of beam specimen for Compressive strength test

Table II shows the compressive strength test results and the changes in the compressive strength.

Table II. Compressive strength test results

Specimen ID	Duration (days)	Avg.Compressive Strength (N/mm^2)	Strength Increase Percentage
M1	28	31.7	-
M2		33.15	4.57
M3		35.65	7.54
M4		33.57	-5.83

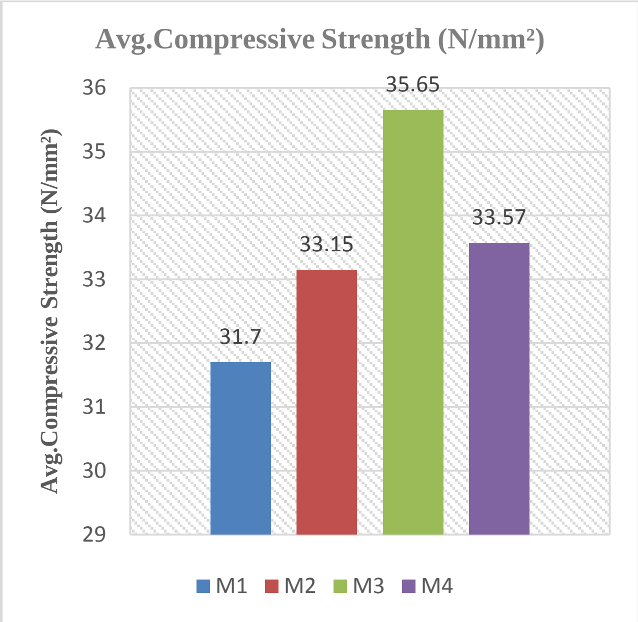

Figure 2. Variability of Compressive strength test results

Figure 2 shows the changes in average compressive strength relative to the cube types. The addition of textile synthetic fibre enhanced the compressive strength of the specimens by at least 4.57% for the specimen M2. The gradual improvement is found by at least 7.54%for the specimen M3 and the decrement of -5.83% for the specimen M4 with respect to the control cube specimens. Fibre volume fraction of 1.0 % gives the high compressive strength compared to other fractions. Therefore, 1.0 %percentage of textile synthetic fibre which will yield the maximum compressive strength of concrete.

B. Tensile strength test results

A total of 12 cylinders of size 100×100×300 mm with four different percentages of textile synthetic fibre volume fractions, such as 0, 0.5, 1.0 and 1.5% and tested.

Figure 3. Instrumentation of beam specimen for Tensile strength test

Table III below shows the average tensile strength recorded during the test and the changes in tensile strength for all mix batches relative to the control batch.

Table III. Tensile strength test results

Specimen ID	Duration (days)	Split Tensile Strength (N/mm²)	Strength Increase Percentage
M1	28	2.97	-
M2		3.20	7.74
M3		3.51	9.68
M4		3.28	-6.55

Figure 4 below shows a graphical representation of the average tensile strength for concrete containing no fibres and concrete containing different volume fractions of fibres.

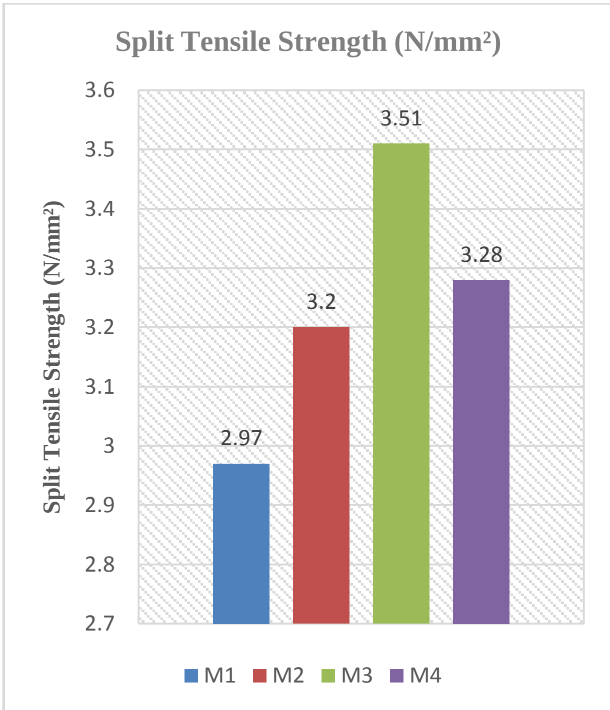

Figure 4. Variability of Tensile Strength results

Figure 4 shows the changes in average tensile strength relative to the cube types. The addition of textile synthetic fibre enhanced the tensile strength of the specimens, were improved by at least 7.74% for the specimen M2. The gradual improvement s found by at least 9.68% for the specimen M3 and the decrement of -6.55% for the specimen M4, with respect to the control cube specimens. Fibre volume fractions, 1.0 % gives high tensile strength comparable to other fractions. Therefore, 1.0 %percentage of textile synthetic fibre which will yield the maximum tensile strength of concrete.

C. Flexural Strength test results

A total of 12 prisms of size 100×100×500 mm with four different percentages of textile synthetic fibre volume fractions, such as 0, 0.5, 1.0 and 1.5% and tested.

Figure 5. Instrumentation of beam specimen for flexural strength test

Table IV below shows the average flexural strength recorded during the test and the changes in Flexural Strength for all mix batches relative to the control batch.

Table IV. Flexural Strength test results

Specimen ID	Duration (days)	Avg.Flexural Strength (N/mm2)	Strength Increase Percentage
M1	28	6.8	-
M2		7.2	5.89
M3		8.1	12.50
M4		7.5	-7.40

Figure 6 below shows a graphical representation of the average Flexural strength for concrete containing no fibres and concrete containing different volume fractions of fibres.

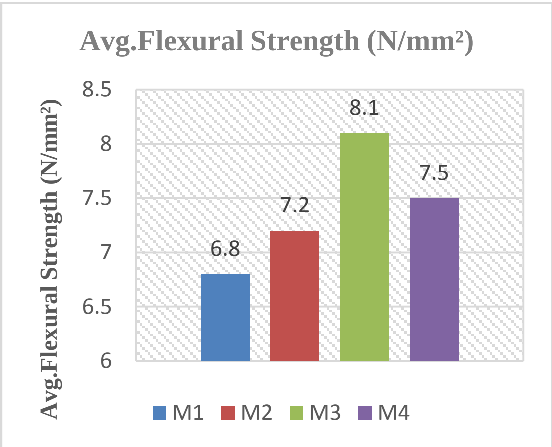

Figure 6. Variability of flexural Strength results

Figure 6 shows the changes in average flexural strength relative to the cube types. The addition of textile synthetic fibre enhanced the flexural strength of the specimens were improved by at least 5.89% for the specimen M2,gradual improvement was found by at least 12.5 for the specimen M3 and the decrement of -7.40% for the specimen M4, respectively with respect to the control cube specimens. Fibre volume fractions, 1.0 % gives high flexural strength compare to other fractions. Therefore, 1.0 %percentage of textile synthetic fibre which will yield the maximum flexural strength of concrete.

Conclusion

This paper has been concerned with the investigation of some mechanical behaviour of concrete with textile synthetic fibres. The experiments were done on compressive, tensile and Flexural the FRC.. Hence the conclusions summarized as: From the result, it is found that the fibre reinforced concrete gives more strength compared to normal concrete.

i. The following quantity of fibre 0.5%, 1.0% and 1.5% was added in concrete and their strength was compared and hence found that the concrete containing 1.0% of fibre has the good strength as compared to others.
ii. From this study, it was found that with the addition of fibres the compressive strength was increased even if, it was insignificant.
iii. The addition of textile synthetic fibres to concrete also improved the tensile strength compared to plain concrete.
iv. Moreover, the control batch specimens containing no fibres failed suddenly once the concrete cracked, while the textile synthetic fibre reinforced concrete specimens were still remaining as a unique cube. This shows that the textile synthetic fibre reinforced concrete has the ability to absorb energy in the post-cracking state.
v. The addition of fibres improved the flexural strength of concrete significantly. The fibre reinforced concrete has the ability to hold on the crack of the concrete and resist the concrete beams from falling apart.
vi. Hence, from this study it can be concluded that the addition of a textile (Structural) synthetic fibres improved the compressive, tensile and flexural strength as well as the ductility of concrete.
vii. As the concrete is a fundamental material in the field of construction engineering, the improvement of its mechanical properties by the addition of this fibre will certainly increase the use of this composite material which will offer more strong and durable structures in the future and will open a new era in the field of construction materials.
viii. By utilizing the nylon fibre waste on the concrete we can able to improve strength of the concrete and reduce the environmental pollution.

Acknowledgements

The authors are thankful to Dr.M. S. Vinaya, Associate Professor, Department of Civil Engineering, Adhiyamaan College of Engineering, Hosur, Tamilnadu for his critical comments and suggestion for improving this paper.

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Please cite this article as: Saravanakumar Jagannathan, Selvaraj Rangasamy & Karthikeyan Kumarasamy. An Experimental Investigation on Nylon Fibre (Textile Waste) Reinforced Concrete. *International Journal of Recent Research and Applied Studies*, 2016, 3, 1(15), 70 - 74.