

An Experimental Investigation of the Behavior of Nylon Fibre Reinforced Concrete

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ABSTRACT

Nylon Fibre is not an absolute new material and it finds its application in many fields such as mostly in the garment interlinings, tooth brush making, fishing nets, ropes, carpets, strings of musical instruments, nets and building structures. In the present times a very promising and prospective direction of using nylon fibre is fibre-concrete and fibre cement reinforced with nylon fibres. The main reason that nylon fibre is so rarely used in the construction industry of India can be attributed to the fact of its non-availability and its high price of shipping but the general trend of increasing production of nylon fibre and reducing cost might change this scenario prevailing in the construction industry. In this thesis work the effects of adding nylon fibre into the concrete cubes as well as cylinders at varying percentages of 0.00%, 0.10%, 0.20% and 0.30% were studied and a thorough research work was carried out with the successful implementation of compressive and tensile strength check of these nylon fibre reinforced concrete cubes and cylinders. The results showed that the effect of addition of Nylon Fibre on concrete resulted in a considerable amount of increase in compressive and tensile strength characteristics. Finally a comparison about the percentage of materials used and strength of concrete is determined.

Keywords: Nylon Fiber Reinforcement, Polypropylene, polyester, nylon, conventional concrete, Flexural Strength; Compressive Strength; Grade of Concrete

1. INTRODUCTION

We already know that concrete is adequately capable for taking compressive stresses but it is weak in tension. As it cannot take the tensile load all by itself so it has to be reinforced with extra reinforcing bars such that the tensile load that is coming on the structure is resisted. So these reinforcing bars can surely resist the tensile force but they fail to prevent the micro-cracks which develop on the concrete surface post construction. More-over for very thin structures the reinforcing bars can't be used. Therefore the need of applying fibres in concrete attracted many researchers.

The concept of fibre reinforcement in concrete is to strengthen the concrete for tensile strength and also to prevent the micro-cracks that develop over the concrete surface. There are various types of fibre that can be used in concrete such as glass fibre, nylon fibre, steel fibre, plastic fibre etc.

Among them Nylon Fibre is very most important. It makes the concrete more ductile in nature. Also the Nylon fibre is a micro fibre; for which it can mixed thoroughly with the concrete resulting in acute prevention of shrinkage cracks efficiently. The benefit of Nylon Fibre reinforced concrete is more prevalent in case of thin structures like cladding panel, light weight concrete, floating concrete etc.

2. GAPS IN STUDY

In the previous research works the investigation was mostly carried out for steel fibres and glass fibres and also for Macro Fibres. A very few research work has been carried out for Micro Fibres. So in this thesis an attempt has been made for introducing Micro Fibre (Nylon-6) to reduce the shrinkage cracking as well as to increase both the tensile as well as compressive strength of concrete.

In the present days steel fibres are used in pavement construction and glass fibres are used for thermal insulation as well as for electrical and sound insulation. But if Nylon Fibre is taken into account, it can be used for very thin structures as well as for cladding panels, light weight concrete, foamed concrete, floating concrete etc. Nylon Fibre reinforced concrete can be prepared with different percentages of nylon and the main aim of this thesis is to find the exact percentage of Nylon for which the concrete gains maximum amount of compressive as well as tensile strength.

3. EXPERIMENTAL STUDY ON FIBRE REINFORCED CONCRETE

3.1 Methodology and Planning of Work

Nylon fibres that are brought for the purpose of mixing must be checked and thoroughly verified as they must be free from surface cracks. It is to be remembered that the nylon fibres are to be used as an admixture and suitable process requires suitable time for mixing ingredients as Indian Standard codes. Care must be taken so as to ensure that the concrete must not be mixed with excess water as water makes less interlocking with nylon fibres .

Target strength of concrete as determined by the equation

Target Nylon Fibres required

$$f'_{ck} = f_{ck} + 1.65x S$$

Or

$$f'_{ck} = f_{ck} + X$$

Whichever is higher.

Where,

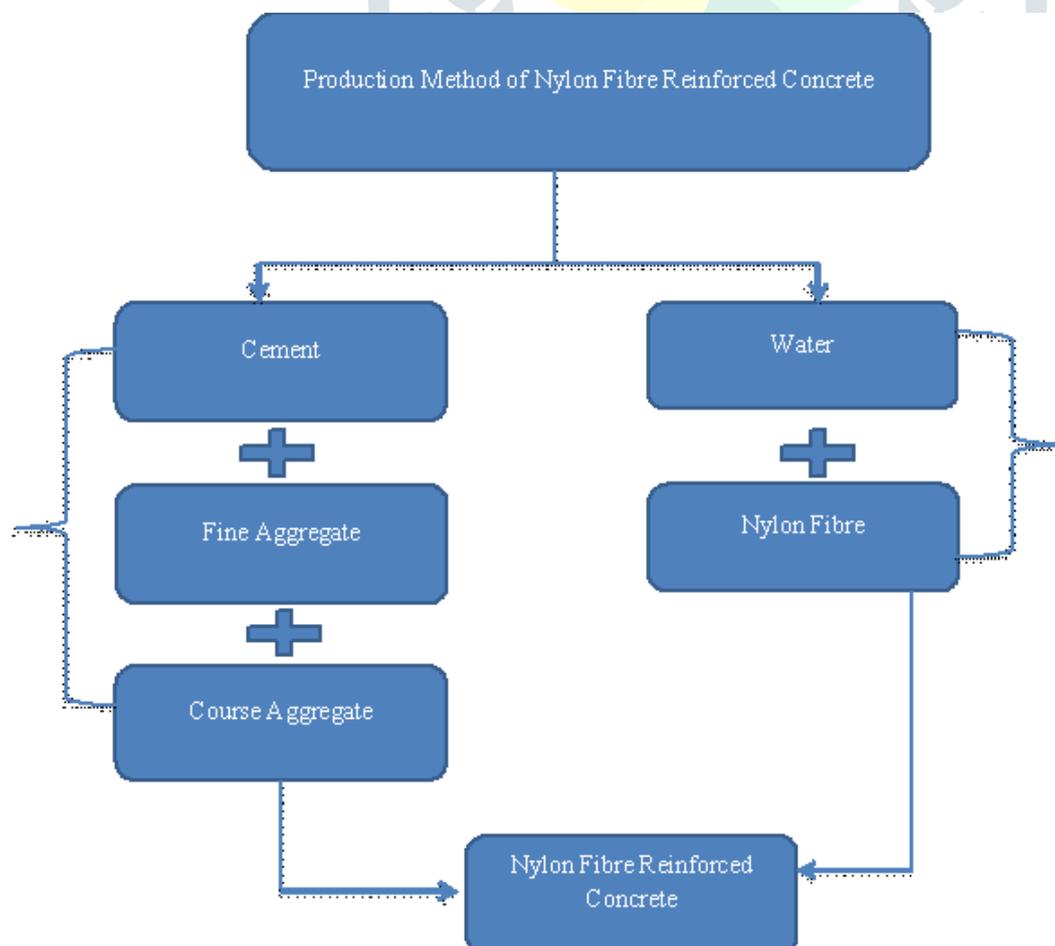
f'_{ck} = target average compressive strength at 28 days,

f_{ck} = characteristics compressive strength at 28 days

S = Standard Deviation, from Table 2 of IS 10262:2019

X = factor based on grade of concrete, from Table 1 of IS 10262:2019

3.2 Flow chart of production of Nylon Fibre reinforced Concrete



3.3 Materials used

The properties of the materials that were used in making fibre reinforced concrete have been depicted below:-

Fine Aggregate:

A sieve analysis with the sample of the fine aggregates was performed resulted in a Fineness Modulus (FM) of 2.805

Specific Gravity=2.56 and Apparent Specific Gravity = 1.98

Bulk density in the loosest state is 1.497 kg/L and in densest state is 1.664 kg/L

Water Absorption = 1.98

Coarse Aggregate:

A sieve analysis test for samples of the course were aggregates was performed resulted in a fineness Modulus of 2.805

Natural aggregates with maximum size of 20 mm used with specific gravity of 2.64 and water absorption of 1.2%

Bulk density in the loosest state is 1.59 kg/L and in densest state is 1.82 kg/L

Cement:

The normal consistency of the given cement sample is – 31%

Specific Gravity= 3.12

The initial setting time of the cement sample = 45 mins.

The final setting time of the cement sample = 9hr 45 mins.

Fineness = 348 m²/Kg

Soundness = 2mm

Nylon Fibre:

The properties of nylon fibre have been depicted in tabular form as:-

| SL NO. | PROPERTY | CRF |
|--------|---------------------|---|
| 1 | MATERIAL | 100 % virgin Nylon 6 fibre |
| 2 | FIBRE CROSS SECTION | Trilobal |
| 3 | FIBRE LENGTH | 18mm |
| 4 | SP. GRAVITY | 1.13 |
| 5 | COLOR | Brilliantly White |
| 6 | MELTING POINT | 220 |
| 7 | CHEMICAL RESISTANCE | Very good against alkali , hydrocarbons |



3.4 Concrete Mix Design:-

| Percentage of Fibre (%) | Cement Content (Kg/m ³) | Water Content (Kg/m ³) | Fine Aggregate Content (Kg/m ³) | Course Aggregate Content (Kg/m ³) | Water/Cement | Fibre Content (Kg/m ³) |
|-------------------------|-------------------------------------|------------------------------------|---|---|--------------|------------------------------------|
| 0 | 394 | 197 | 649 | 1092 | 0.5 | 0 |
| 0.1 | 394 | 197 | 649 | 1092 | 0.5 | 0.394 |
| 0.2 | 394 | 197 | 648 | 1090 | 0.5 | 0.788 |
| 0.3 | 394 | 197 | 648 | 1090 | 0.5 | 1.182 |

4. TESTING OF SPECIMEN

4.1 Compressive Strength Test:

The compression test is carried out on specimens of both cubical and cylindrical shapes. For compressive strength test, cubes of size 150mm X 150mm X 150mm were casted. Cubes for compressive strength check are tested at 28 days using compression testing machine.



TABLE: 28TH DAY COMPRESSIVE STRENGTH FOR CUBE

| ITEM | NYLON FIBRE CONTENT | ULTIMATE LOADS (KN) | AVERAGE ULTIMATE LOADS (KN) | COMPRESSIVE STRENGTH (N/mm) |
|------------|---------------------|---------------------|-----------------------------|-----------------------------|
| NORMAL MIX | 0.00% | 590 | 613.33 | 27.25 |
| | | 610 | | |
| | | 640 | | |
| NFM1 | 0.10% | 590 | 621.66 | 27.69 |
| | | 625 | | |
| | | 650 | | |
| NFM2 | 0.20% | 725 | 745 | 33.11 |
| | | 745 | | |
| | | 765 | | |
| NFM3 | 0.30% | 475 | 495 | 22 |
| | | 485 | | |
| | | 525 | | |

4.2 Cylinder Specimen under Compression Test:

The compression test is carried out on a specimen; which is cylindrical in shape. For compressive strength checking, cylinder of 150 mm diameter and 300 mm height were casted and they were tested for compressive strength on 28th day using compression testing machine.



| ITEM | NYLON FIBRE CONTENT | ULTIMATE LOADS (KN) | AVERAGE ULTIMATE LOADS (KN) | COMPRESSIVE STRENGTH (N/mm) |
|------------|---------------------|---------------------|-----------------------------|-----------------------------|
| NORMAL MIX | 0.00% | 472 | 490.66 | 21.8 |
| | | 488 | | |
| | | 512 | | |
| NFM1 | 0.10% | 474 | 500.33 | 22.24 |
| | | 502 | | |
| | | 525 | | |
| NFM2 | 0.20% | 580 | 596 | 26.48 |
| | | 596 | | |
| | | 612 | | |
| NFM3 | 0.30% | 380 | 396 | 17.6 |
| | | 388 | | |
| | | 420 | | |

4.3 SPLIT TENSILE STRENGTH TEST:

For Splitting Tensile strength test, cylinders of 150mm diameter and 300mm height were casted and then tested after 28 days.



TABLE: 28TH DAY SPLIT TENSILE STRENGTH FOR CYLINDER

| ITEM | NYLON FIBRE CONTENT | ULTIMATE LOADS (KN) | AVERAGE ULTIMATE LOADS (KN) | SPLIT TENSILE STRENGTH (N/mm) |
|------------|---------------------|---------------------|-----------------------------|-------------------------------|
| NORMAL MIX | 0.00% | 120 | 133.33 | 1.88 |
| | | 150 | | |
| | | 130 | | |
| NFM1 | 0.10% | 210 | 225 | 3.18 |
| | | 240 | | |
| | | 225 | | |
| NFM2 | 0.20% | 290 | 280 | 3.96 |
| | | 270 | | |
| | | 280 | | |
| NFM3 | 0.30% | 180 | 190 | 2.68 |
| | | 200 | | |
| | | 190 | | |

5. RESULTS AND DISCUSSIONS

From the compressive strength test of cubical as well as cylindrical specimens; it was found that the compressive strength of cube as well as cylindrical specimens is maximum in case of 0.2% addition of Nylon Fibre in the concrete. The compressive strength of concrete increases with the increment of fibre content percentage; up to 0.2% addition of nylon fibres but the strength decreases above addition of 0.2% of Nylon Fibre in the concrete.

The split tensile strength of concrete increases with the 0.2% addition of nylon fibres in the concrete but it decreases above 0.2% of Nylon Fibre addition.

6. CONCLUSION:

- The compressive strength and tensile strength of concrete increase with the increasing percentage of Nylon fibre.
- The concrete gains maximum strength both compressive as well as split tensile with the addition of exactly 0.2% of Nylon Fibres.
- The micro cracking can also be reduced with the addition of the nylon fibre (Nylon-6).
- So the Nylon-6 fibre can be used; which would increase the compressive as well as tensile strength.

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