Experimental Investigation on Strength Properties of Nylon Fiber Reinforced Concrete Pavements

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***Abstract*- To improve properties of concretes and reduce the drawbacks of conventional concrete a lot of researches are now being conducted to use fiber in concretes . Fiber reinforced concrete is the concrete containing fibrous materials which increases its structural integrity. It controls cracking due to plastic shrinkages and to drying shrinkages, reduces permeability of concrete, thus reducing the bleeding of water. Some types of fibres produce greater impact resistence, high strength properties in concrete. Nylon fibre is selected for study. The strength study is conducted on concrete with different dosage 0%, 0.25%, 0.50%, 0.75%, 1% of nylon fibre.**

Key words: Conventional concrete, Nylon fibre.

I.INTRODUCTION

Concrete is a composite material of fine aggregates and coarse aggregates which are binded with a cementecious material. In most of the concretes Ordinary Portland Cement (OPC) is used as the cementecious material. However Asphalt concrete are also frequently used in concrete pavements. The first strip of concrete pavement was completed in 1893. Concrete is extensively using for paving highways and airports as well as business and residential streets. Concrete pavements are made with dowels or with reinforcement as purpose. Even though concrete pavements are better than bituminous pavements it has many drawbacks like cracks , abrasion etc. The cracks are generally developed with time and stresses to penetrate the concrete, which affects the waterproofing properties and exposing the interior of the concrete to the damaging substances like moisture, acids, etc. Fibre Reinforced Concrete (FRC) increase tensile strength , reduce the air voids , increases durability , creep resistance, etc. has been recognized that the addition of small, closely spaced and uniformly dispersed fibers to concrete would act as crack arrester and would substantially improve its static and dynamic properties. Nylon is a soft, heat resistant (Thermal conductivity = 0.25 W/(m·K)), with more compact molecular structure have high melting point ((256 °C/492.8 °F) and excellent abrasion resistance is selected as fibre here. The nylon fibers stepped up the performance after the presence of cracks and sustained high stresses when compared to other FRC. In this paper, the strength properties of nylon-fiber-reinforced concrete were under investigation, in comparison with conventional concrete.

II. EXPERIMENTAL PROGRAM

A. Materials Used

1) Cement: The materials used in concrete are Ordinary Portland Cement (OPC) of grade 53 confirming to IS: 12269-2013.

Table 1: Properties of cement.

PARTICULARS	**VALUES**
Fineness of cement	7%
Specific gravity of cement	3.15
Standard consistency of cement	32.33%
PARTICULARS	**VALUES**
Initial setting time	34 min
Final setting time	360 min
3rd day compressive strength	30
7th day compressive strength	39

2) Coarse Aggregates: Coarse aggregates of maximum size 20mm are used for experiment. Laboratory tests are conducted on coarse aggregates. Table 2 shows the tests conducted and results obtained.

Table 2. Properties of coarse aggregate

PROPERTIES	**VALUE**
Specific gravity	2.8
Bulk density	1.62
Void ratio	0.79
Porosity	0.44
Fineness Modulus	8.61

3) Fine Aggregate: Crushed stone sand with size between 150 microns and 4.75mm is used as fine aggregate . Tests conducted on fine aggregates. Table 3 shows the tests conducted and results obtained.

Table3. Properties of fine aggregate

PROPERTIES	VALUE
Specific gravity	2.6
Bulk density	1.89 g/cm^3
Void ratio	0.13
Porosity	0.12
Fineness Modulus	3.95

3) Water: Potable water is used ..

4) Nylon: The fibre used in the study is nylon. The nylon fibre was bought from Meher International, Surat.

Table 4. Properties of nylon

PROPERTIES	VALUE
Type	Monofilament
Diameter (mm)	0.03
Aspect ratio	633.33
Specific gravity	1.14
Water absorption, %	66.66
Density, kg/m^3	657

5) Superplasticizer: the superplasticizer used in the experiment is Master Glenium bought from chalai, Trivandrum.

Table 5. Properties of superplasticizer

Colour	Amber
Structure	Poly carboxylic ether based
Density	1.082-1.142 kg/lts
Chlorine content	< 0.1
Alkaline content	< 3
Dosage	1%

B. Mix Design

Mix design of M25 grade concrete is proportioned as per IRC : 44 2008 with the concrete mix proportion of 1:1.91:3.97 (cement:fine aggregate:coarse aggregate)with water cement ratio 0.45 are used for both conventional concrete and concrete with nylon fibres. Table 6 shows the details of mix.

Table 6. Mix details

Cement	331 kg/m^3
Coarse aggregate	1316 kg/m^3
Fine aggregate	632 kg/m^3
Water	149 ltrs
Admixture	1%
W/C ratio	0.45

A dosage of 0%, 0.25%, 0.5%, 0.75% and 1% of nylon fibre are used in mixtures for the study.

C. Specimen Preperation And Curing

The mixing of concrete was done in a 'batch concrete mixer' as per the proportion. Specimens of cube, cylinder, beam and disc are made for each dosage of nylon fibres. 9 cubes of size 15cmx15cmx15cm, 6 cylinders of diameter 15cm and height 30cm, 3 discs of diameter 15cm and height 5cm and 3 beams of size 10cmx10cmx50cm are made for each dosage of nylon fibre. Thus 105 specimens are made. While casting the specimens proper compaction was provided with a vibrator and finished with a trowel. The casted specimens are allowed to set for 24 hours. After that specimens are removed from the mould and placed in a water tank for curing up to 28 days. Figiure 1 shows mixing and figure 2 shows the specimens.

Figure 1.mixing of concrete

Figure 2. specimens

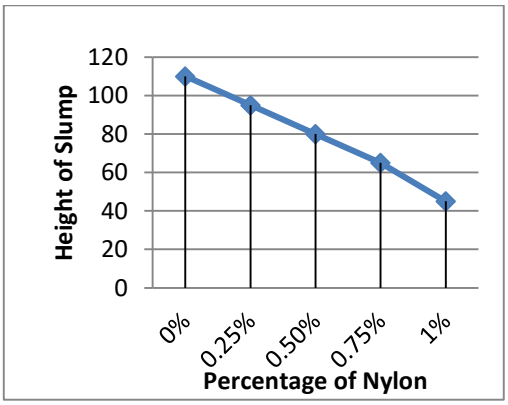
D. Tests On Fresh Concrete

To achieve a best hardened concrete tests on fresh concrete is conducted. In addition to having a suitable composition in terms of quality and quantity of cement, aggregate, and admixtures should satisfy a number of requirements like compactablity, finishablility, flowability mixability or collectively termed as workability. IS: 6461 (PART VII) defines workability as that property of freshly mixed concrete or motar which determines the ease and homoginity with which it can be mixed , placed , compacted, and finished. However by checking and controlling the uniformity of the workability , it is easier to ensure a uniform quality of concrete and hence uniform strength for a particular job. The empirical tests used in this study are

1. Slump test.
2. Compacting factor test.

Slump Test: Slump test is most widely used because of the simplicity of apparatus required and the test procedure. It indicates the behavior of a compacted concrete under gravitational force. The test is suitable in both laboratory and site condition. Graph 1 shows the comparison of slump value of concrete with different dosage.

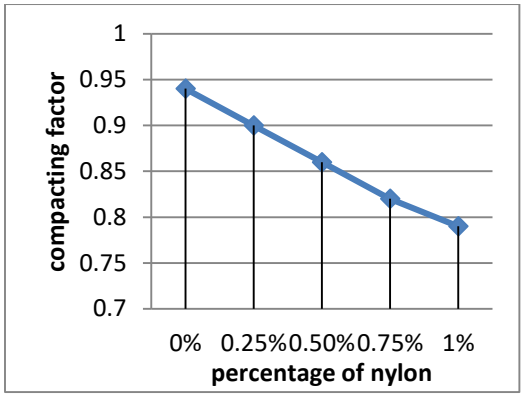
Figure 3. slump test



Graph 1. Comparison of slump value

Compacting Factor Test: Compacting factor test gives the behaviour of fresh concrete under the action of external forces. The test is proper in laboratory conditions. Graph 2 shows the comparison of compacting factor of different mixes.

Figure 4. Compacting factor test



Graph 2. Comparison of compacting factor

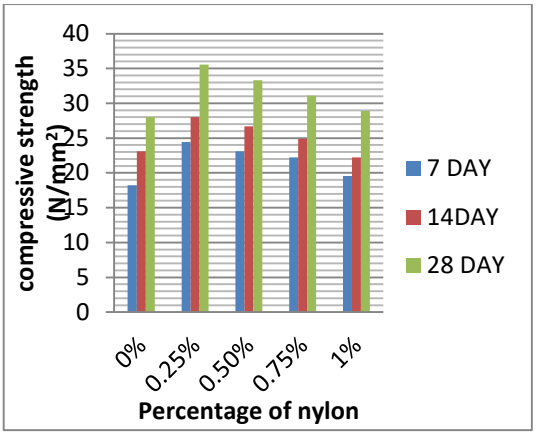
E. Tests On Hardened Concrete

1) Compressive Strength Test: Since most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength it is an important test for strength study.it is carried out in cube of size 15x15x15cm. The cube is removed from water and allow some time to dry. After cleaning the bearing surface of the testing machine the specimen is placed on it. Align the specimen centrally on the base plate of compression strength testing machine. By Rotate the movable portion gently by hand, till the top surface of the specimen touches. Apply continuous load at the rate of 140 kg/cm^2/minute till the specimen fails and note down the failure load. The compressive strength after 7, 14, 28 days curing are conducted for conventional concrete. Compressive strength of concrete with different dosage 0.25% to 1% are also conducted after 7, 14 and 28 days of curing. Table 7 shows the compressive strength of different mixes.

Figure 5. Compressive strength testing.

Table 7. Compressive strength of different dosage.

Percentage of nylon	Compressive strength (N/mm^2)		
	7 day	14 day	28 day
0%	18.22	23.11	28
0.25%	24.44	28	35.55
0.50%	23.11	26.67	33.33
0.75%	22.22	24.9	31.11
1%	19.56	22.22	28.89



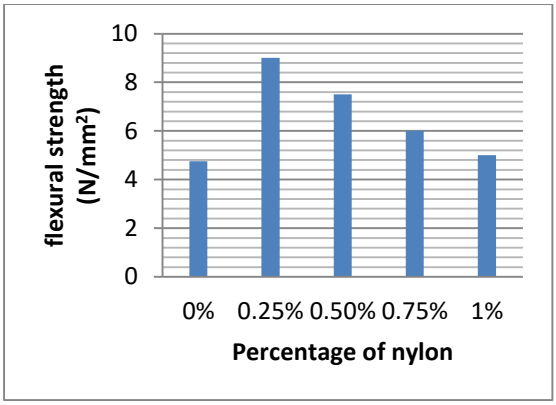
Graph 3. Comparison of compressive strength

2) Flexural Strength Test: Flexural test evaluates the ability of unreinforced concrete beam or slab to withstand failure in bending. The flexural test conducted here is three point load test. The test conducted on beam of size 10cmx10cmx50cm. After removing from water and allowing some time for drying the specimen is placed on loading points so as to adjust 1/3 loading position along the two lines 13.3cm apart. The load is applied without shock and increased at a rate of 7kg/cm^2/min. Load is increased until the specimen fails and the maximum load is recorded. The appearance and features of the fractured faces are noted. The flexural strength after 7, 14, 28 days curing are conducted for conventional concrete and with different dosage 0.25% to 1% of nylon are also conducted after 7, 14 and 28 days of curing. Table 8 shows the flexural strength of different mixes.

Figure 6. Flexural strength test

Table 8. Flexural strength of different dosage.

Percentage of nylon	Flexural strength (N/mm²)
	28 day
0%	4.75
0.25%	9
0.50%	7.5
0.75%	6
1%	5



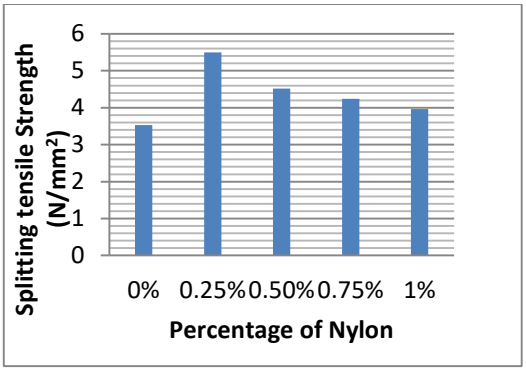
Graph 4. Comparison of flexural strength

3)Splitting Tensile Strength Test: Tensile strength of concrete is one of the basic and important properties . Splitting tensile strength test is a method to determine the tensile of concrete. The test is conducted on compression testing machine. The test is conducted on cylinder of diameter 15 cm and height 30cm. After 28 days of curing take the wet specimen from water. Dry the specimen. To ensure the specimen are on the same axial place diametrical lines are drawn on the two ends. Keep plywood strip on the lower plate and align the specimen on place. Place the other ply wood strip on above the specimen and bring down the upper plate to touch the plywood strip. Apply continuous load without shock at a rate of a 14-21kg/cm^2/mint. The breaking load is noted.

Figure 7. Split tensile testing

Table 9. Splitting tensile strength of different dosage

Percentage Of Nylon	Splitting tensile strength (N/mm^2)
0%	3.53
0.25%	5.5
0.50%	4.52
0.75%	4.24
1%	3.96



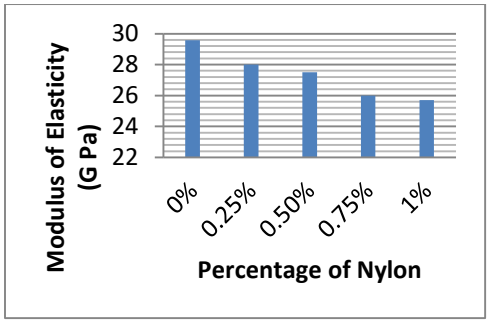
Graph 5. Comparison of splitting tensile strength

4)Modulus Of Elasticity Test: Modulus of elasticity test is included among other strength test because the elastic modulus of the hardened concrete is a function of modulus of elasticity of aggregates and the cement matrix and their relative proportions. The average compressive strength of concrete from cube specimen is determined. The compressometer is attached to the specimen and the specimen centrally spaced on compressive strength testing machine. The load is increased approximately at the rate of 140kg/cm^2 per min till an average stress of (C+5) kg/cm^2 is reached (C = 1/3rd of average cube strength already fond). The load is maintained for 1 min and reduced gradually to average stress of 1.5 kg/cm^2 compressometer readings are taken. The load is raised at the specified rate for the second time to an average stress of (C+1.5)kg/cm^2. The load is again reduced and readings are again taken at 1.5 kg/cm^2. During third cycle readings taken at 10 equal intervals up to an average stress of (C+1.5)kg/cm^2 . after removing compressometer the specimen is replaced and loaded up to failure and maximum load is noted. Table 10 shows the results obtained.

Figure8. Modulus of elasticity testing

Table 10: modulus of elasticity of different dosage

Percentage of nylon	Modulus of elasticity (G Pa)
0%	29.567
0.25%	28
0.50%	27.5
0.75%	26
1%	25.7



Graph 6. Comparison of splitting tensile value of different dosage

5) Impact Resistence Test: Impact resistance test of concrete was done on a disc of size 15cm diameter and 5cm height. The test is conducted by dropping a hammer weighing 4.54kg from a height of 45.7cm to repeatedly on 6.4 cm diameter hardened steel ball. The test is conducted after 28 days of curing. Number of blows required to visible a crack and up to ultimate failure is noted. Table 11 shows the results obtained.

Figure 9. Impact resistance testing.

Table 11. Impact index of different dosage

Percentage of nylon	No. of blows for first crack	No. of blows for ultimate crack	Impact index
0%	10	12	1.2
0.25%	14	50	3.57
0.50%	13	30	2.3
0.75%	15	40	2.67
1%	20	30	1.5

III. CONCLUSION

From the experimental study following conclusions are arrived.

- Workability of fibre reinforced concrete decreased with increase in fibre content. The slump value and compacting factor of mixes are found less than conventional concrete.
- The concrete shows its maximum strength when 0.25% of nylon fibre dosage concrete
- Addition of 0.25% of nylon shows an improvement of 26.96% in compression strength.
- In the case of flexural strength , it shows an improvement of 89.47% when compared to conventional concrete.

- Maximum increase of split tensile strength shows 55.81%. when compared with conventional concrete.
- The modulus of elasticity decreases with increase in nylon . it may be because the concrete become rigid due to presence of fibre.
- Peak impact resistance where shown in 0.25% nylon fibre added concrete when compared to conventional concrete.
- In normal concrete the disc brokened in two blows after first crack but others shows more blows. It is because the nylon gives good reinforcement and the concrete become more ductile.

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