International Journal of Modern Research in Engineering & Management (IJMREM)
||Volume|| 3 ||Issue|| 1 ||Pages|| 06-13 || January 2020 || ISSN: 2581-4540

Effect Of Amount And Length Of Nylon Fibres On The Properties Of Concrete

[1,]Abdul Rahman Shaikh, [2,]Muhammad Jaffar Memon , [3,]Manthar Ali Keerio, [4,]Zahid Hussain Khaskheli*

[1] M.E student Department of Civil Engineering, Mehran University of Engineering and Technology, Shaheed Zulfiqar Ali Bhutto Campus, Khairpur Mir's, Karachi, Sindh, Pakistan.

[2,] Assistant Professor, Department of Civil Engineering, Mehran University of Engineering and Technology, Shaheed Zulfiqar Ali Bhutto Campus, Khairpur Mir's, Karachi, Sindh, Pakistan.

[3,4,] Civil Engineering Department, Quaid-e-Awam University of Engineering, Science and Technology (Campus) Larkana, Sindh, Pakistan

---ABSTRACT---

Nylon is a synthetic fibre, used in plenty of applications due to its strength, durability and flexibility. However, its after-use leads to serious environmental problems. If successfully used in concrete to reinforce it, will not only solve environmental issues but will be helpful in strengthening the concrete. The aim of this research was to investigate experimentally, effects of Nylon fibres on the properties of concrete in fresh and hardened state. In the research work, nylon fibres of length 10mm & 20mm were used in concrete with different percentages by weight of cement. The experimental work results showed, that the workability of nylon fibre reinforced concrete decreases with increasing percentage of nylon fibres. The optimum amount and length of nylon fibres for compressive strength and tensile strength was 1% at 20mm length respectively. The increase in compressive and tensile strength was 31% and 66.67%, as compared to un-reinforced concrete

KEYWORDS: Nylon Fibres, Workability, Compressive strength, Tensile strength, Fibre reinforced concrete

Date of Submission: Date, 19. December 2019 ⟺ Date of Publication: 05. January 2020

I. INTRODUCTION

Second to water, concrete is the most consumed substance with three tons per year for every individual [1]. Though it has high compressive strength, however very week to resist tensile stresses, less energy absorbent and less ductile [2]. Steel bars have been most commonly used in concrete to resist tensile forces, however due to their extra load and corrosion issues fibres are gaining more popularity these days [3]. It is also a technique to reduce the robustness and sinking the contraction due to unsoundness by introducing the little amount of undersized fibres typically between 0.25% - 3% in the concrete [4]. The addition of the fibres in concrete has an effect to flyover the fissure gaps and develop the resistance against tension causing forces of fibres reinforced concrete over plain concrete [5][6]. Moreover, the fibres enhance the performance of concrete under shock blows and reduce the plastic shrinkage cracks [7][8][9]. In fibre reinforced concrete, fibres bridge the gaps and prohibit the crack propagation initially as minor cracks and then to major cracks [10]. Fibres actually hold the existing cracks by confining and prevent its disintegration and spalling of concrete [11]. Amongst the various types of fibres available, nylon Fibres are gaining a rising acceptance [12]. Nylon was the first commercially successful synthetic thermoplastic polymer [13]. Nylon being tough is difficult against tear and possess excellent abrasion resistance. It is a hygroscopic material and tends to absorb moisture from surrounding [14]. Hence lead to decreased workability. Nylon fibre decomposes under sunlight so often UV resistance additives are used. The fibres actively get engagement after existence of small cracks and can carry high loads [15]. These fibres are made from synthetic polymer which can be melted and processed into any shapes [16][17]. Presence of nylon fibres provide durability to the concrete and prevent spalling of concrete cover by its confining characteristics [18][19].

II. MATERIALS AND METHODS

Cement and Aggregate : Cement was purchased from local market and tested for its chemical composition by X-ray fluorescence test and hill sand passing through 4.75 mm sieve was used in this research. The coarse aggregate with saturated surface dry condition with maximum size 19 mm was used in this study. These materials are shown in Fig 1. The physiochemical properties of materials are given in Table 1 and Table 2.

Nylon Fibres : Nylon Fibres of length 10mm and 20mm purchased from local market were used in the study. Nylon Fibres were in form of filament coils as shown in Fig 2. These Fibres were then cut into length of 10 mm and 20mm as shown in Fig 3. A sample of NF used in research work is shown in Fig 4.

Mix Design : Mix design was prepared based on ACI method for plain and reinforced concrete. The fibres were used in two different lengths i-e 10mm and 20 mm with a fixed water-cement ratio 0.55. The nylon fibres were used by weight of cement in varying percentages as 0.25%, 0.5%, 0.75%, 1%, 1.25% and 1.5%. The concrete mixes were prepared for plain and reinforced concrete. The amount of cement, fibres, fine aggregate and coarse aggregate was finalized in mix design based on target strength and water-cement ratio. Detail of mix proportion of plain and reinforced is provided in Table 3. In the research hand mixing was adopted, to make sure that fibres get mixed with rest of the constituents properly. The quantity of materials was weighed as per mix design. The ground was cleaned properly and moisture with damp cloth before mixing of materials. The coarse aggregates were placed followed by sand and mixed thoroughly. Cement was added to this mixture and nylon fibres were evenly added as shown in Fig 5. Tap water was added in the mix as per mix design. The mixing was continued for 6-8 minutes until a uniform mix was observed. To encourage a uniform distribution of fibres throughout of the concrete, fibres were added to the concrete mix slowly and evenly before the water, aggregates and cement were fully mixed. The mixing technique was repeated for all the batches of research project.

After mixing of concrete, fresh concrete was ready to undertake workability test and casting of concrete into molds were carried out to meet the scope of research project. The cylindrical specimens of 100x200mm^2 were used in this study. These molds were filled with plastic concrete in three equal layers and compacted on vibrating table as shown in Fig 5. After 24 hours of casting these specimens were placed for curing period of 28 days. Four cylindrical specimens for tensile and four for compressive strength were prepared with each percentage of fibres. The specimens were carried out of curing tanks on the day of testing.

III. RESULTS AND DISCUSSIONS

Workability Test: The workability test was conducted immediately after mixing of FRC as per ACI standards C-143. The observed slump values are provided in the Table 4. As shown in the table, control mixes achieved maximum slump values. However, the slump values started decreasing with the addition of fibres in the mix, with maximum reduction observed at maximum fibres content. These results can be due lack in the cohesion of unreinforced concrete mix resulting in more workability [20]. It was observed after comparing the results of that slump value decreased with the addition of fibres to concrete. Workability was greatly decreased for the fibres of length of 20mm. The fibre length also influenced slump values, fibres with 20mm showed lower values compared to 10 mm fibre length. The reduction in the values of slump can be attributed to water absorption capacity of fibres which is in the range of 25% to 40% [21]. It was concluded from observed results that fibre reinforced concrete shows reduced slump values and needs more water or suitable water-reducing admixture. Therefore, superplasticizer was used in order to maintain the slump values. The results of control and fibre reinforced concrete with different fibre lengths are provided in the Fig 6 and Table 4 was taken during workability test.

Compressive Strength : The test was conducted as per ACI standards C-318-19. The observed experimental values are provide in Table 5, and for better understanding and comparative analysis results are depicted on the Fig 7. The test results showed that the optimum values of compressive strength are observed at 1% addition of fibres by weight. Thereafter, declining path in the values was reported. Addition of fibres beyond optimum amount might be increasing permeability of concrete, resulting in decreased strength [3]. The compressive strength at 1% addition of fibres having length 10mm was 30.6% higher compared to un-reinforced concrete. Whereas, with 20mm length it was 31% higher. However, Abdullah et al (2017) reported 0.5% as the optimum amount of fibres in FRC [21]. The difference in optimum percentage of fibres in fibre reinforced concrete can be due to different types of fibres. Though the addition of both short and long fibres increased the compressive strength significantly compared to un-reinforced concrete. However, longer length fibres produced higher strength than shorter length fibres at 1% addition. This may be due to their more ductile nature.

Tensile Strength : Tensile strength test was conducted on concrete cylinders as per ACI standards C-496. In cylindrical specimens two types of failure mechanisms were observed. During experimental testing it was reported that plain concrete specimens were completely splitting into two parts, whereas those with nylon fibres there was only a single crack initially started from top to bottom. A cracking line was also visible along the length of specimen at this stage. The small cracks propagated and joined other cracks to form big cracks and lead to failure of specimen.

It was witnessed during the test that fibre reinforced concrete does not lead to sudden failure but by initiation of cracks. It was further reported that tensile strength increases with the addition of fibres in concrete and the optimum dosage of fibres for tensile strength was 1%. Thereafter, reduction in strength was noticed. This can be due to fibres making concrete more porous compared to un-reinforced concrete. The maximum tensile strength of concrete at 1% fibres with 10mm length was reported 63% higher than un-reinforced concrete. Moreover, the increase in strength at 1% dosage with 20mm length was 66% which was higher than 10mm NFRC and un-reinforced concrete. The tensile strength results are provided in Table 6 and Fig 8.

FIGURES and Tables

Table 1. Chemical composition of cement

Elements	OPC (%)	Class F ASTM C618
SiO_2	14.5	70% (min) $SiO_2 + Al_2O_3 + Fe_2O_3$
Al_2O_3	3.94	-
Fe_2O_3	3.56	-
CaO	57.0	-
K_2O	0.51	-
TiO_2	-	-
MgO	1.62	-
Na_2O_3	-	-

(a) (b) (c)

Fig.1 (a) Ordinary Portland cement (b) Fine aggregate (c) Coarse aggregate

Fig. 2 Nylon Fibres filament coils

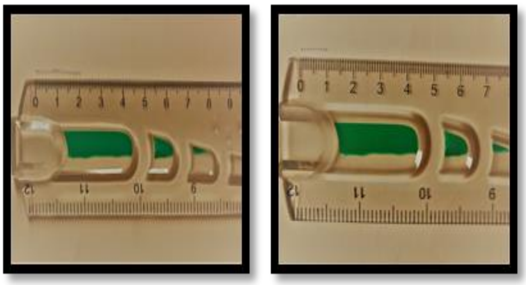

Fig. 3 NF of length 20mm and 10mm.

Fig. 4 Nylon Fibres

Table 2. Physical properties of materials

Property	**Fine Aggregate**	**Coarse Aggregat e**	**OPC**
Specific gravity (SG)	2.55	2.68	3.1
Fineness modulus	2.34	-	-
Water Absorption (%)	1.1	0.98	-
Surface area (cm^2/g)	-	-	4805.8
Size	<4.75 mm	<20 mm	<63 micron

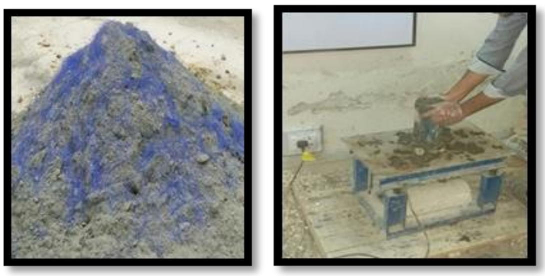

Fig. 5 Mixture and compaction of specimens

Table: 3 Mix design of concrete

Ratio 1: 2: 3

Mix ID (Batch)	Code	Cement (% age)	F.A (%.age)	C.A (% age)	Addition of Nylon Fiber w.r.t weight of cement (%.age)	Length of NF (mm)	w/c ratio
B1	Standard	100	100	100	0	--	0.55
B2	0.25NF10	100	100	100	0.25	10	0.55
B3	0.5 NF10	100	100	100	0.5	10	0.55
B4	0.75 NF10	100	100	100	0.75	10	0.55

B5	1 NF10	100	100	100	1	10	0.55
B6	1.25 NF10	100	100	100	1.25	10	0.55
B7	1.5 NF10	100	100	100	1.5	10	0.55
B8	0.25NF20	100	100	100	0.25	20	0.55
B9	0.5 NF20	100	100	100	0.5	20	0.55
B10	0.75 NF20	100	100	100	0.75	20	0.55
B11	1 NF20	100	100	100	1	20	0.55
B12	1.25 NF 20	100	100	100	1.25	20	0.55
B13	1.5NF 20	100	100	100	1.5	20	0.55

Table 4. Slump values in (mm) of NFRC for NF of 10 & 20 mm
Control Mix Slump value = 31mm at 02 % SP

	NF 10mm	NF 20mm	SP (%)
NF 0.25	29	26	2.5
NF 0.5	36	32	2.5
NF 0.75	48	44	2.5
NF 1	33	29	3
NF 1.25	47	46	3
NF 1.5	28	25	3.5

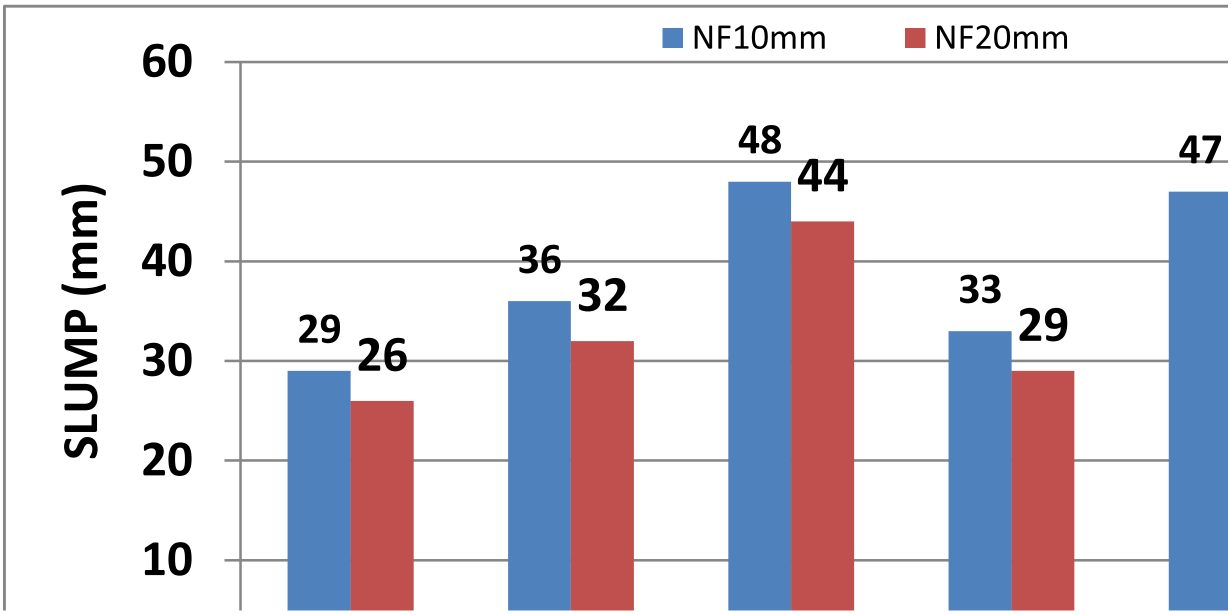

Fig. 6 Slump values of concrete

Table 5. Compressive strength NFRC with fibre length 10mm and 20 mm

Mix	Compressive strength NF-10mm	Compressive strength NF-20mm
NF0.25	24.86	25.35
NF0.5	25.01	27.04
NF0.75	25.32	28.62
NF1	28.74	28.82
NF1.25	26.08	28.72
NF1.5	24.53	28.3

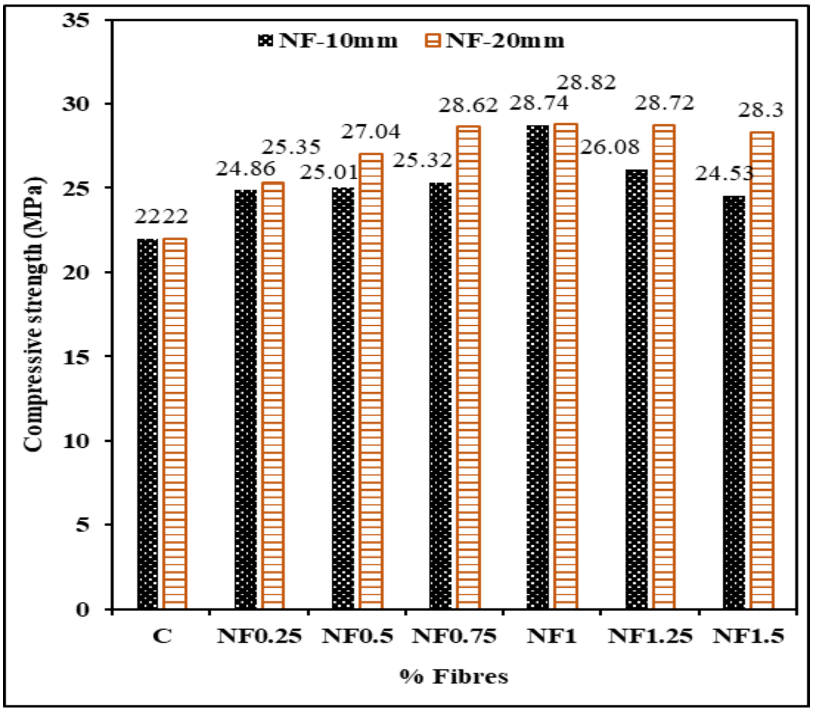

Fig. 7 Compressive strength of NFRC with fibre length 10mm and 20 mm

Table 6 Tensile strength of Nylon Fibres Reinforced concrete

Mix	Tensile Strength (MPA) NF-10mm	Tensile Strength (MPA) NF-20mm
NF0.25	2.63	2.68
NF0.5	2.72	2.95
NF0.75	2.91	3.32
NF1	3.43	3.5
NF1.25	2.68	2.96
NF1.5	2.45	2.83

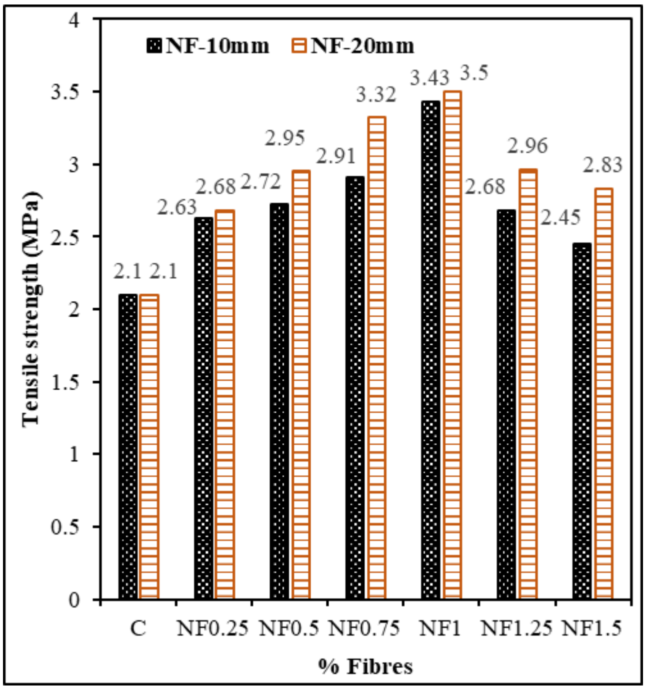

Fig. 08Tensile strength of Fibre reinforced concrete

IV. CONCLUSION

On the basis of experimental work carried out at Structural Engineering Laboratory following conclusions were drawn.

1. The addition of nylon fibres in concrete decrease the slump value significantly due to high water absorption of fibres. Therefore, water reducing admixture is highly recommended with nylon fibre reinforced concrete.

2. It was also observed that fibre length have significant effect on the workability of concrete. Increasing the length of fibres decrease the workability.

3. The nylon fibres addition increases the compressive strength. However, the optimum amount for maximum compressive strength was observed 1%. Thereafter, reduction in the compressive strength values was reported. Though increasing the length of fibres increased compressive strength. However, difference in strength value was not much significant.

4. The nylon fibres have substantial impact on the tensile strength of concrete. The addition of fibres in concrete increased tensile strength 66.67 % compared to un-reinforced concrete. The optimum amount of fibres for tensile strength was 1%. However, the length of fibres significantly influenced the tensile strength of concrete.

REFERENCES

[1] C. R. Gagg, Cement and concrete as an engineering material: An historic appraisal and case study analysis, Eng. Fail. Anal., vol. 40, no. May, 2014, 114–140.
[2] S. S.A, A comparative Study of Confinement Models. 1982, pp.985.
[3] I. Ahmed, Samiullah Sohu, Z. H, Influence of Fibre Length on the Behaviour of Polypropylene Fibre Reinforced Cement Concrete, Civil Engineering Journal, 4(9), 2018, 2124-2131.
[4] J, Keer, Fibre Reinforced Concrete in Concrete Technology and Design, New Reinfo. Swamy RN, Surry University Press, London. 1984.
[5] W. Y, B. S, and L. V.C, Experimental Study of Synthetic Fibre Reinforced Cementitious Composite," J. Mater. Sci., vol. 22(12), 1987, 4281–4291.
[6] M. S. Bentur, Fibre Reinforced Cementitious Composites, Elsevier A. 1990.
[7] C. Petrus, H. A. Azhar, Compressive strength of concrete with fibres at elevated temperature, Civil Engineering Journal, 78(5), 2016, 71-74.

[8] P. P. K. Wang, S.P. Shah, Plastic shrinkage cracking in concrete materials—Influence of fly ash and fibers, ACI Mater. J, 98(6), 2001, 458-464.

[9] M. A. D. Bayasi, Effect of exposure to elevated temperature on polypropylene fiber-reinforced concrete, ACI Mater. J, 99(1), 2002, 22-26.

[10] S. Song, S. Hwang, Strength properties of nylon- and polypropylene-fiber-reinforced concretes, Cem. Concr. Res, 35(8), 2005, 1546-1550.

[11] Z. B. H. Toutanji, S. McNeil, Chloride permeability and impact resistance of polypropylene-fiber-reinforced silica fume concrete, Cem. Concr. Res., 28(7), 1998, 961-968.

[12] M. M. Z. Bayasi, Application of fibrillated polypropylene fibers for restraint of plastic shrinkage cracking in silica fume concrete, ACI Mater. J., 99(4), 2002, 337-334.

[13] B. R. H. Vishal Gadgihalli, M. S. Ramya, S. Sindhu, Analysis of properties of concrete using nylon fiber as fiber reinforcement admixture," Int. J. Res. – Granthaalayah, 5(4), 2017, 63-66.

[14] M.L. Allan, Permeability and microstructure of plain and polypropylene fibre reinforced grouts," Cem. Concr. Res., 24(4), 1994, 671-681.

[15] H. Vogler, Wettstreit um die polymidfaseen" chemie in unserer zeit," chemie unserer zeit, 2013, 62-65.

[16] M. Koban, 1995, Nylon plastics hand book.

[17] J. G. Heo, C. Sanjayan, G. Han, Critical parameters of nylon and other fibres for spalling protection of high strength concrete in fire, Mater. Struct., 44(3), 599-610.

[18] L. Guncheo, H. Dongyeop, Combining polypropylene and nylon fibers to optimize fiber addition for spalling protection of high-strength concrete, Constr. Build. Mater., 34(3), 2012, 313-320.

[19] A. D. Figueiredo and M. R. Ceccato, Workability Analysis of Steel Fiber Reinforced Concrete Using Slump and Ve-Be Test, Mater. Res., 18(6), 2015, 28-35.

[20] A. G. Musa, N. Rajoria, A. G. Mohammed, Effect of Palm Oil Fiber on Laterized Concrete. Int. J. Eng. Technol. Manag. Appl. Sci., 5(5), 2017, 686-695.