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Mechanical Properties of Latex Modified Nylon Fibre Reinforced Concrete with Partial Replacement of Cement by Flyash

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ABSTRACT

Nylon fibers are used as strengthening material to increase the mechanical properties of concrete.In this study mechanical properties of concrete containing latex modified nylon fiber reinforced concrete was assessed with fractional substitution of cement by flyash for M40 grade concrete at 7 days, 14 days and 28 days of curing. The dosage of fibres used in this study was 0.05%, 0.1% and 0.15% of volume fraction. Cement was replaced with fly ash at a percentage of 10%, 15%, 20% by weight. SBR latex was varied at a rate of 0.05%, 0.1%, 0.15% to the total cementitious content in concrete. Cube, cylinder and prism specimens are tested to determine the compressive, split tensile and flexural strength at 7 days and 28 days curing. Results shows that Nylon fiber reinforced concrete with 0.15% of fiber, 0.05% SBR Latex with 10% has higher influence on flexural strength, split tensile strength and compressive strength of concrete.

Key words : *Nylon Fiber, Fly ash, SBR Latex, Mechanical properties*

Introduction

Concrete is broadly utilized synthetic construction material. Concrete is very good at compressive strength and very weak at resisting tensile forces. In order to enhance the tensile properties fibres are incorporated in concrete. These fibers in the concrete distribute and orient randomly along the volume of the concrete. They are very helpful in preventing cracks and controlling the crack propagation (Sridhar *et al.*, 2021). Mechanical properties of Nylon fiber reinforced concrete increases with increase in fibre addition upto 1% by weight of cement. Beyond that the compressive strength decreases whereas split tensile strength increases about 70% when related to conventional concrete (Anirudh Swami *et.al.*, 2016). The properties of Nylon Fiber Reinforced Concrete (NFRC) with recycled aggregate with 25% replacement showed higher strength when associated to concrete with polypropylene fibers with 25% recycled aggregate (Vineetha *et al.*, 2017). Concrete with flyash replacement of 15% with coconut fiber of 0.15% shows higher strengths than other replacements (Kaviya and Chamundeeswari, 2015). Concrete containing 40% flyash with 2% hooked end steel fibers shows better mechanical properties than samples containing only hooked end steel fibres (Amirtharaj and Vinod Kumar, 2018). Latex modified reinforced concrete beams with 10% SBR latex shows improved ductility and energy ab-

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sorption than those of control beams(Palson and Vidivelli *et al*., 2018). Concrete of M40 grade with 10% dosage of polymer and fly ash was attaining higher compressive strengths against 20% and 30% fly ash and polymer content (Vipin *et al*., 2017). Strength properties of concrete with 0.5% nylon fiber increases up to 17% under compression,21% under tensile loading and 13% under flexure when related with control specimens. Mechanical property of cement-based mortar improves with nylon fiber as additive which can be effectively used as sustainable product to conserve marine environment (Hanif *et al*., 2017). Nylon fiber with volume fraction 0.05%,0.10% and 0.15% with latex addition of 5%, 10% and 15% may be used for road pavements. Improvement in the latex will improve the flexural strength, permeability resistance and impact resistance with increase in volume fraction of nylon fiber. These improvements contribute to the strong bond between the nylon fiber and latex (Rio *et al*., 2014). Concrete with polypropylene fiber with volume fraction 0.5% shown improvement in the mechanical property of concrete between ranging between 4.3% to 6.3% due to improved distribution of fibers in the concrete (Songa *et al.,* 2005). Concrete with nylon fibers increases the mechanical properties by transferring and distribute the stresses through cracks (Teeranai *et al*., 2020). Increasing the amount of latex in polymer modified concrete reduces the strength. Butantifoaming agent (defoamer) and correct curing method, can improve the strength properties (Farhad *et al.,* 2013). In this study, nylon fiber are subjected to SBR latex treatment at a dosage of 0.05%,0.10% and 0.15% by weight of cement to improve their performance in concrete. Treated nylon fibers were used with different dosage of fly ash replacement for cement and the comparison of performance has been reported.

Materials and Mix Proportion

The material properties used for the investigation and concrete mix used is discussed below

Cement

Ordinary Portland cement of 53 grade cement with specific gravity 3.15, initial setting time of 45min was used as per IS 12269,2013.

Fly ash: Fly ash used was collected from local fly ash brick manufacturing agency. Fly ash which is oven dried and free from moisture was used for casting.

Water: Potable water which is free from impurities has been used for both casting and curing of specimens.

Aggregate

Sand having specific gravity of 2.65 has been used as fine aggregate. The water absorption percentage of fine aggregate were found to be 0.90%. Crushed angular stone aggregates having specific gravity of 2.69 has been used as coarse aggregate in concrete. The water absorption percentage of coarse aggregate were found to be 0.40%.

Nylon fibre

Nylon Fiber of length 18mm, melting point 220 ^oC and tensile strength of 896-965MPa was used for this study which is shown in Figure 1. Nylon fibers were pre-treated using SBR latex to improve the bonding between fiber surfaces and concrete grid.

Fig. 1. Nylon Fiber

Styrene Butadiene Rubber Latex

SBR Latex is a cement bonding agent to progress the bond strength, tensile strength and chemical confrontation. The properties of SBR Latex are shown in the Table 1.

Table 1. Properties of SBR Latex

Properties of SBR Latex	
Polymer Type	Styrene Butadiene
Color	White
pH	9.5 to 10.50
Form	Liquid
Solid Content	50%

Mix proportions of concrete

Concrete confirming grade M40 has been used to determine the performance of treated fibers in concrete. Details of concrete mix proportions as per IS10262 2019 are shown in Table 2.

Experimental Investigation

All the materials of required quantities which are very clean and free from organic matter are used for the investigation. Based on the design mix calculation the cement, coarse aggregate and fine aggregate were collected and mixed thoroughly by using mechanical mixer. Initially SBR latex treated or untreated nylon fiber were dispelled in to the cement and mixed thoroughly in order to distribute the nylon fiber homogeneously into the mix. To all test specimens the concrete was placed into the moulds in three layers by tamping with tamping rod and these moulds were kept on vibrator table for vibration for one minute and the vibration should maintain constant for all test specimens. For compressive strength, cube specimens of size 15 cm x 15 cm x 15 cm, for flexural strength studies, prism specimens of size 10 cm x 10 cm x 50 cm and cylinder specimens of size 30 cm height and 15 cm diameter for split tensile strength studies were cast. After curing period of 7 and 28 days the test specimens were tested for compressive strength, split tensile strength and flexural strength. The details of the specimens are arrayed in Table 3.

Results and Discussion

Compressive strength

Compressive strength is determined with samples of size 15cm x 15cm x 15cm. The compressive strength results of 7 days and 28 days at different dosage of flyash, Natural fibres and SBR latex are shown in Figure 2. From the Figure. 2 the maximum compressive strength for NFRC6 with 10% Fly ash at 7days and 28 days is 34.8N/mm^2 and 55.7N/mm^{2}respectively which is 27% and 19% higher than the conventional concrete. Similarly, in the case of NFRC with 15% and 20% Fly ash maximum compressive strength was obtained for NFRC20 and NFRC33 which was about 12% and 2% higher than conventional concrete at 28 days of curing. Considering the all NFRC mix maximum compressive strength was obtained for NRFC6,i.e Nylon fiber reinforced concrete with 0.10% Nylon fiber, SBR latex 0.05% and Fly ash 10% by weight of cement. Specimens with SBR Latex 0.10% and 0.15% by weight of cement tends to have reduction in compressive strength irrespective of the percentage of fibers and fly ash. Moreover, treatment of nylon fiber with SBR latex has contributed to the strength of the concrete. Similarly, it was observed that NFRC specimens with 20% fly ash the compressive strength reduces with the increase in SBR latex and fiber content. The compressive strength decreased as more latex was added (for a given nylon fiber volume fraction). The addition of latex is known to enhance the tensile strength of concrete, rather than its compressive strength. This may be due to latex film interfering with the hydration reaction. At a fixed latex level, however, there was at most a minor increase in the compressive strength as the nylon fiber volume fraction was increased. In this research, adding latex prevented the strength reduction resulting from fiber balling because the latex improved the dispersion of the fibers.

Split Tensile Strength

From the Figure 3 it is detected that the split tensile strength of concrete is maximum for NFRC6, NFRC20 and NFRC33 at 7 days and 28 days curing. At 7 days curing maximum split tensile strength for NFRC6, NFRC20 and NFRC33 is of 2.49 N/mm^2 ,2.18 N/mm^2, 1.76 N/mm^2 which was 52%,33% and 17% respectively higher than control specimen. Similarly, at 28 days curing NFRC6, NFRC20 and NFRC33 split tensile strength is 4.1 N/mm^2, 3.64 N/mm^{2}and 3.15N/mm^{2}respectively. Split tensile

Table 2. Concrete Mix Proportion

Replacement of cement with Flyash	10%	15%	20%
Cement (kg/m^3)	368.64	348.16	327.68
Fly ash (kg/m^3)	40.96	61.44	81.92
Water Content (kg/m^3)	147.45	147.45	147.45
Fine Aggregate (kg/m^3)	644.71	642.13	639.56
Coarse Aggregate (kg/m^3)	1237.01	1232.07	1227.13

Table 3. Specimen specification

Specimen Designation	Nylon Fiber(%)	SBR Latex (%)	Fly Ash (%)
NFRC1	0	0	10
NFRC2	0.05	0	10
NFRC3	0.10	0	10
NFRC4	0.15	0	10
NFRC5	0.05	0.05	10
NFRC6	0.10	0.05	10
NFRC7	0.15	0.05	10
NFRC9	0.05	0.10	10
NFRC10	0.10	0.10	10
NFRC11	0.15	0.10	10
NFRC12	0.05	0.15	10
NFRC13	0.10	0.15	10
NFRC14	0.15	0.15	10
NFRC15	0	0	15
NFRC16	0.05	0	15
NFRC17	0.10	0	15
NFRC18	0.15	0	15
NFRC19	0.05	0.05	15
NFRC20	0.10	0.05	15
NFRC21	0.15	0.05	15
NFRC22	0.05	0.10	15
NFRC23	0.10	0.10	15
NFRC24	0.15	0.10	15
NFRC25	0.05	0.15	15
NFRC26	0.10	0.15	15
NFRC27	0.15	0.15	15
NFRC28	0	0	20
NFRC29	0.05	0	20
NFRC30	0.10	0	20
NFRC31	0.15	0	20
NFRC32	0.05	0.05	20
NFRC33	0.10	0.05	20
NFRC34	0.15	0.05	20
NFRC35	0.05	0.10	20
NFRC36	0.10	0.10	20
NFRC37	0.15	0.10	20
NFRC38	0.05	0.15	20
NFRC39	0.10	0.15	20
NFRC40	0.15	0.15	20

strength decreases for latex content of 0.15%. Also, it is noted that addition of nylon fibers beyond 0.15% gives negative effect on the tensile strength. The reason behind is the occurrence of unequal distribution of fiber in the mixture.

Flexural Strength

From Figure.4, it was noted that maximum flexural strength was obtained for NFRC6, NFRC20 and NFRC33 for both 7 days and 28 days of curing. It was observed that flexural strength was about 49%, 40% and 39% higher than conventional concrete for NFRC6, NFRC20 and NFRC33 respectively for 7 days of curing. Similarly, for 28 days of curing flexural strength was 46%, 40% and 24% higher for NFRC6, NFRC20 and NFRC33 respectively. When tensile loading or flexural load is applied the latex film increases the bond between materials and concrete. The tests with varying nylon fiber volume fraction showed that the flexural strength also increased with the nylon fiber volume fraction. Reduction in strength was observed in beyond 0.1% of nylon fibers.

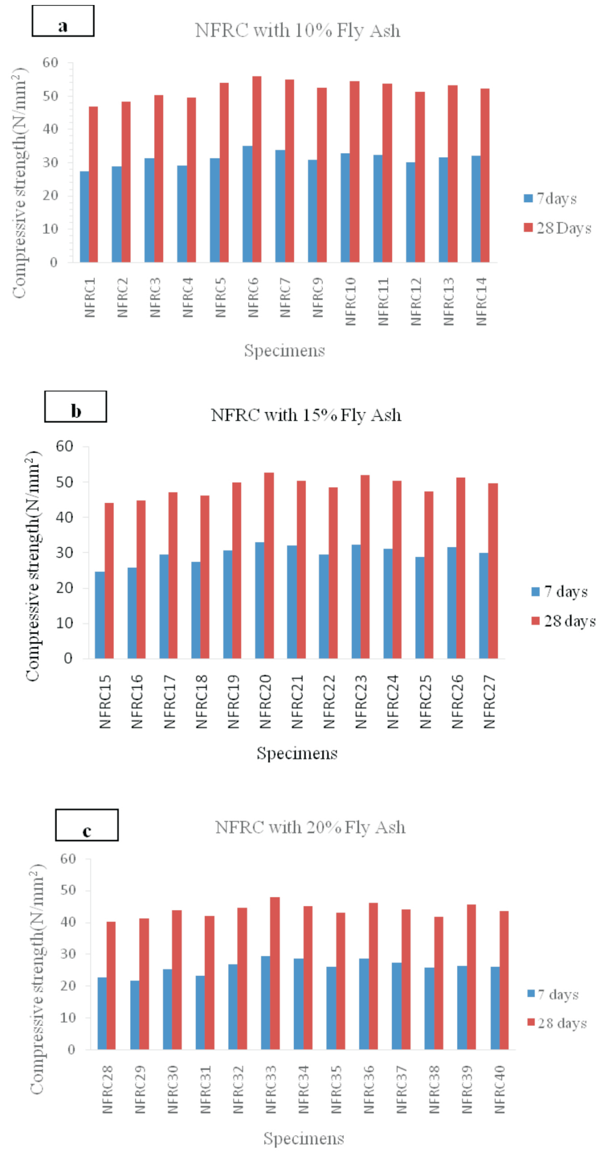

Fig. 2. Compressive strength of NFRC a) with 10 % Fly ash b) 15% Flyash c) 20% Flyash

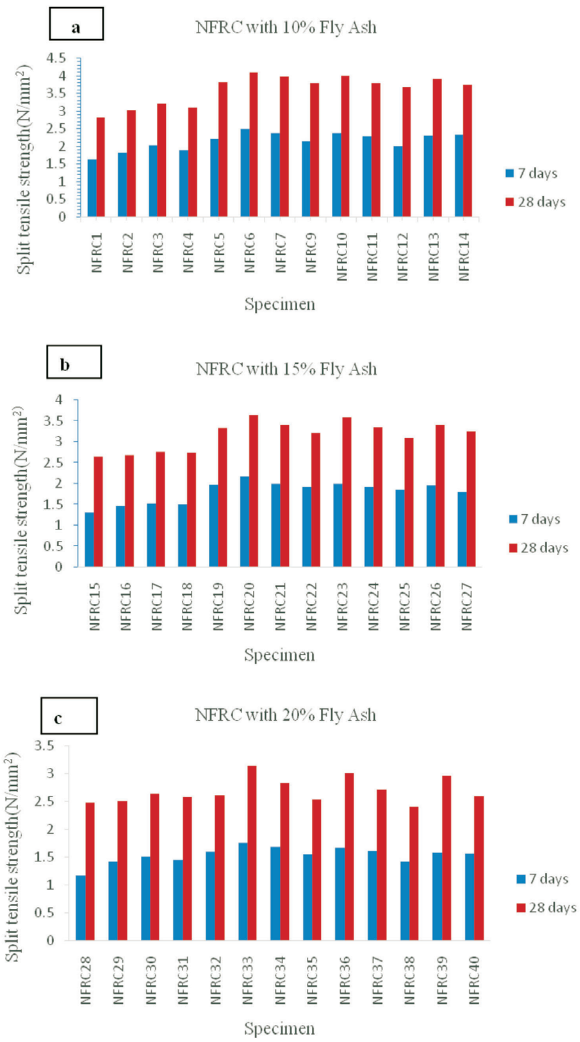

Fig. 3. Split tensile strength of NFRC a) with 10 % Fly ash b) 15% Fly ash c) 20% Flyash

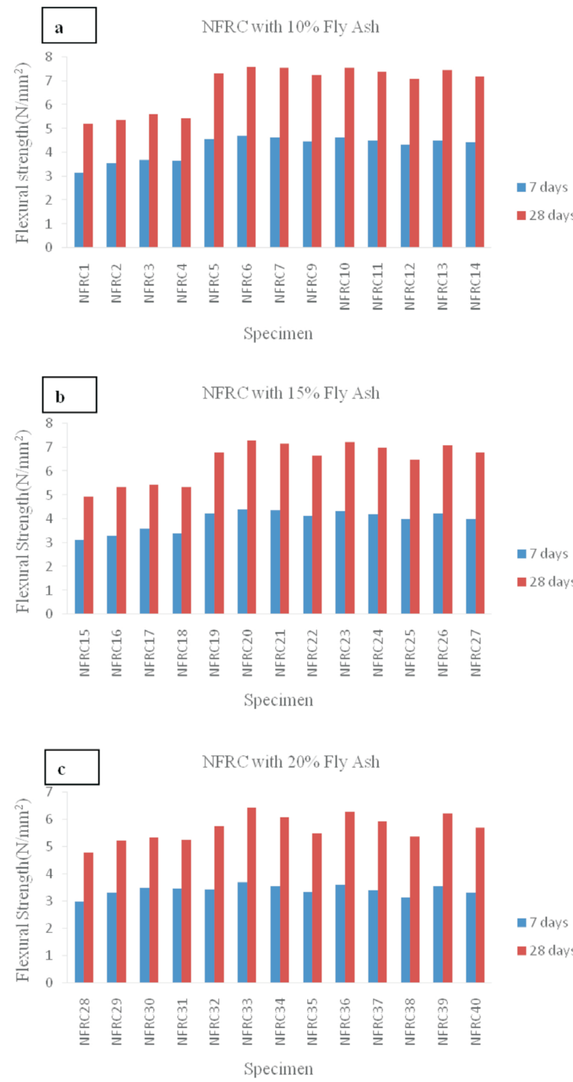

Fig. 4. Flexural strength of NFRC a) with 10 % Fly ash b) 15% Fly ash c) 20% Fly ash

Conclusion

- Inclusion of SBR latex treated nylon fiber has considerably improved the mechanical strengths of FRC. The optimal combination was obtained as 10% replacement of fly ash to cement with addition of 0.1% nylon fiber and 0.05% SBR latex to the total volume of concrete.
- Compared with control specimen inclusion of 0.1% nylon fiber with 0.05% of SBR latex and 10% replacement of fly ash by cement increases the compressive strength by 27% & and 19% respectively at 7 days and 28 days curing.
- The split tensile strength was found to be maximum for concrete with 0.01% nylon fiber with 0.05% of SBR latex and 10% replacement of flyash by cement was found to be increased by 52% and 46% at 7 days and 28 days curing when compared with control specimen.
- The flexural test results showed the supremacy of treated fibers in the flexural strength enhancement of concrete prisms. Adding 0.01% nylon fiber with 0.05% of SBR latex and 10% replacement of flyash by cement improved the flexural strength by 49% and 46% for 7 and 28 days of curing respectively.
- Addition of fibers augmented the overall strength characteristics of the concrete than the control concrete. In particular, treated nylon fi-

ber has been found promising in increasing flexural properties of reinforced concrete prism due to its high tensile strength.

References

Amirtharaj, J. and Vinod Kumar, R. 2018. Effect of Fly Ash on Fiber Reinforced Concrete-A Durability Approach. *International Research Journal of Engineering and Technology*. 5(12) : 643-647.

Anirudh, Swami and Shishr, Gupta, 2016. Use of Nylon Fiber in Concrete. *International Journal for Scientific Research & Development*. 4(5) : 2321-0613.

Bureau of Indian Standards, 2013,IS 12269-Ordinary Portland cement 53 grade specifications

Bureau of Indian Standards., 2019, IS10262-Concrete Mix Proportioning - Guidelines

Farhad, Nabavi., Shami, Nejadi and Bijan, Samali, 2013. Experimental Investigation on Mix Design and Mechanical Properties of Polymer (Latex) Modified Concrete. *Advances in Material Research*. 687 : 112-117

Hanif, I.M., Noor Syuhaili, M.R., Hasmori, M.F. and Shahmi, S.M. 2017. Effect of nylon fiber on mechanical properties of cement based mortar. *IOP Conf. Series: Materials Science and Engineering.* 271 : 1-7

Kaviya, K. and Chamundeeswari, J. 2015. Utilisation of Fly Ash and Fibre in Concrete. *Indian Journal of Science and Technology*. 8(32) : 1-7.

Palson, P. and Vidivelli, B. 2018. Flexural Behaviour of Latex Modified Fly Ash Based Reinforced Concrete Beams. *International Journal of Applied Engineering Research*. 13(5) : 2918-2925.

Rio-Oh, Dong Hyun Kim, and Chan-Gi Park. 2014.Durability performance of latex modified nylon fiber reinforced concrete for precast concrete pavements applications. *Indian Journal of Engineering and Material Sciences*. 21 : 49-56.

Songa, P.S., Hwang, S. and Sheu, B.C. 2005. Strength properties of nylon- and polypropylene-fiber-reinforced concretes. ,*Cement and Concrete Research*. 35 : 1546-1550.

Sridhar, Jayaprakash., Jegatheeswaran, Dhanapal., Vivek Deivasigamani and Elias, G. 2021. Flexural Behaviour of Chicken Mesh Ferrocement Laminates with Partial Replacement of Fine Aggregate by Steel Slag. *Advances in Material Science and Engineering*: 1-9.

Teeranai, Srimahachota, Hiroshi, Yokota and Yoshikazu, Akira. 2020 Recycled Nylon Fiber from Waste Fishing Nets as Reinforcement in Polymer Cement Mortar for the Repair of Corroded RC Beams. *Materials*. 13: 1-14.

Vineetha, V. V. and Arya Aravind. 2017. Mechanical Properties of Hybrid Fibre Reinforced Concrete using Recycled Aggregate. *International Journal of Advances in Scientific Research and Engineering*. 3(5) : 47-56.

Vipin, Halde, Monali, Ingle, Ganesh, Wayal, Girish, Sharma, Poonam, Ingole and Amit Kumar. 2017. Effect of Fly Ash and Polymer on Compressive Strength of Concrete. *International Research Journal of Engineering and Technology*. 4(6) : 413-418.