International Journal of Civil and Structural Engineering– IJCSE
Volume 1 : Issue 4 [ISSN 2372-3971]
Publication Date : 27 December,2014

Experimental study on strength and durability properties of fiber reinforced concrete

Gurunaathan K[1], Seenivasan G[2], and Thirugnanam.G.S[3]

***Abstract* - In this paper, the strength of concrete cubes and cylinders cast using M40 grade concrete and reinforced with recron3s, polypropylene fibers and mineral admixtures have been presented. Also, hybrid fibers with recron3s and polypropylene have been used in concrete matrix to study its impact on strength and durability properties. The recron3s, polypropylene and hybrid [polypropylene and recron3s] fibers of various proportions i.e., 1% of recron3s fiber, 1% of polypropylene fiber (Boasee fiber) and 1% of hybrid fibers each of 0.5% by volume of cement with admixtures of 1% by weight of cement have been used in concrete mixes. The result obtained has been analyzed and compared with the control specimen (0% fiber). It clearly shows the compressive strength values for M40 grade without and with fibers.**

***Keywords* - Concrete, Polypropylene fiber-reinforced, Recron3s fiber-reinforced, Compressive strength, Split tensile strength.**

Introduction

Civil structures made of steel reinforced concrete normally suffer from corrosion of steel by certain salts, which results in the failure of those structures. There are many ways to minimize the failure of the concrete structures made of steel reinforced concrete. The custom approach is to adhesively bond fiber polymer composites on to the structure. This also helps increase the toughness and tensile strength thereby improving the cracking and deformation characteristics of the resultant composite. But, this method adds another layer, which is prone to degradation. These fiber polymer composites have been shown to suffer from degradation when exposed to marine environment due to surface blistering. As a result, the adhesive bond strength is reduced, which results in the delamination of the composite. Another approach is to replace the rods with fibers to produce a fiber reinforced concrete [FRC].

[1]Gurunaathan.K.
Research Scholar, Anna University, Chennai, Tamilnadu
India

[2]Seenivasan G.
PG student, IRTT,Erode, Tamilnadu,
India

[3].Thirugnanam.G.S.
Professor and Head, Dept. of Civil Engineering, IRTT,Erode, Tamilnadu
India

Basically, this method of reinforcing the concrete substantially alters the properties of the non-reinforced cement-based matrix which is brittle in nature having little tensile strength compared to the inherent compressive strength. The principal reason for incorporating fibers into a cement matrix is to increase the toughness and tensile strength, and improve the cracking deformation characteristics of the resultant composite.

In order for fiber reinforced concrete (FRC) to be a viable construction material, it must be able to compete economically with existing reinforcing systems. Only a few of the possible hundreds of fiber types have been found suitable for commercial applications. This paper deals specifically with the concrete reinforced with the "polypropylene fibers " and "recron3s fibers". The objective of this research is to explore the properties of polypropylene fibers and recron3s fibers in specific environments to which the commercial FRCs are exposed.

Objectives of the study

The objectives of this work is to study the durability properties of M40 grade of concrete reinforced individually with fly ash, silica fume, 1% of recron3s fibers and polypropylene fibers, and also with hybrid fibers consisting of 0.5% recron3s and 0.5% polypropylene fibers, and to evaluate their strengths at 7, 14, and 28 days.

Experimental significance

In this experimental investigation, an attempt has been made to study the compressive strength of recron3s fibers, polypropylene fibers and hybrid [polypropylene and recron3s] fiber reinforced concrete. The characteristics of fibers used in this investigation are as shown in Table I.

TABLE I

Material	Length	Diameter
Polypropylene fiber	6mm	0.05mm
Recron3s fiber	12mm	0.05mm

SEEK DIGITAL LIBRARY

Materials and Mix proportions

Materials

The materials used for this experimental work are cement, sand, water, fly ash, silica fume, recron3s fiber, Polypropylene fiber and Super plasticizer.

Cement: Ordinary Portland cement of 53 grade conforming to Indian Standards (IS) 12269-1987 was used in this experimentation.

Sand: Locally available sand zone II with specific gravity 2.65, water absorption 2% and fineness modulus 2.92, conforming to I.S. 383-1970.

Coarse aggregate: Coarse aggregate of sizes 20mm and 12 mm have been selected for the study. The fineness modulus of 5.94 with specific gravity of 2.7 and 10 mm size having specific gravity of 2.70, fineness modulus of 2.73, conforming to IS 383-1970 have been used.

Water: Potable water was used for the experimentation.

Fly ash: Fly ash obtained from local suppliers was used in this investigation which satisfied IS: 3812 with Specific gravity and Blaine specific surface area of 2.30 and 2.68 m^2/kg, respectively.

Silica Fume: Silica fume imparts improvement to rheological, mechanical and chemical properties. It improves the durability of the concrete by reinforcing the microstructure through filler effect and thus reduces segregation and bleeding. Silica fumes of specific gravity 2.34 was used in powder form in the study.

Super Plasticizer: To impart additional workability a super plasticizer (Conplast SP430) 0.6 % to 0.8% by weight of cement as per IS – 9103:1999 was used.

Recron3s Fiber: Recron3s is for improving the quality of construction. It also results in saving of cement and sand and helps completing targeted job earlier. Recron-3s does not replace structural and load bearing reinforcement materials. Recron3s prevents the micro shrinkage cracks developed during hydration, making the structure/plaster/component inherently stronger. Further, when the loads imposed on concrete approach that of failure cracks will propagate, sometimes rapidly. A structure free from micro cracks prevents migration of water or moisture through-out the concrete. This in turn helps prevent the corrosion of steel used for primary reinforcement of the structure thereby resulting in the longevity of the structure.

Polypropylene Fiber: Polypropylene fiber (Boasee Fiber), a synthetic carbon polymer, is produced as continuous mono – filaments, with circular cross section that can be chopped to required lengths and the fibers are tough but with low tensile strength and modulus of elasticity. Their ability to cause interference with the capillary forces by which water bleeds to the surface of concrete reduces the risk of plastic settlement due to water evaporation.

A blend of recron3s and Polypropylene fiber can combine structural elements with plastic cracking in fresh concrete and drying shrinkage cracking in hardened concrete and also improves post-cracking toughness. It increases resistance to spalling in fire situation as well.

Mix proportions

In this study, the normal strength concrete of M40 grade was considered. BIS code procedure as per IS: 10262-1982 was followed for finding the mix proportions of the concrete specimen. Water binder ratio was considered for M40 grade as 0.4. Table II shows the summary of materials required for control concrete mix used in this investigation.

TABLE II MIX PROPORTIONS OF CONCRETE

Concrete grade	Materials required per m^3 of Concrete			
	Cement (kg)	*F.A (kg)*	*C.A (kg)*	*Water (lit)*
M40	345	687	1121	138

The various mix combinations of blended concrete are shown in Table III. In various mix proportions, the super plasticizer (Conplast SP430) of 0.6 % to 0.8% by weight of cement was used.

Experimental program

Casting: For compressive strength test, cube specimens of dimensions 150 mm × 150 mm × 150 mm were cast using M40 grade of concrete with 1% of recron3s fiber, 1% of Polypropylene fiber and 1% of hybrid [Polypropylene and Recron3s] fiber by volume of cement, separately. Vibration was given to the moulds using table vibrator. The top surface of the specimen was leveled and finished. After 24 hours, the specimens were demoulded and transferred to curing tank wherein they were allowed to cure for 7 days, 14 days and 28 days. After 7, 14 and 28 days of curing, these cubes were tested on compression testing machine. The failure load was noted. In each category, three cubes were tested and their average value is reported.

Figure 1Casting of specimens

SEEK DIGITAL LIBRARY

TABLE III DETAILS OF MIX PROPORTION FOR CONCRETE MIX M40

Mix No.	C (kg/m³)	C.A. (kg/m³)		F. A. (kg/m³)	Recron 3s fiber	Poly propylene fiber	Fly ash	Silica fume	Water (kg/m³)
		20 mm	*12 mm*						
A	394	725	483	740					157.6
B	394	725	483	740			✓		157.6
C	394	725	483	740	✓		✓		157.6
D	394	725	483	740				✓	157.6
E	394	725	483	740	✓			✓	157.6
F	394	725	483	740			✓	✓	157.6
G	394	725	483	740	✓		✓	✓	157.6
H	394	725	483	740		✓	✓		157.6
I	394	725	483	740		✓		✓	157.6
J	394	725	483	740		✓	✓	✓	157.6
K	394	725	483	740	✓	✓	✓		157.6
L	394	725	483	740	✓	✓		✓	157.6
M	394	725	483	740	✓	✓	✓	✓	157.6

Figure 2 Curing of specimens

Figure 3 Compressive strength test

Compressive Strength Test

Results of compressive strength for M40 grade of concrete on cube specimens are shown in Table IV.

There is a significant improvement in the compressive strength of concrete because of the high pozzolanic nature of the silica fume and its void filling ability.

The compressive strength of concrete cube specimens was investigated by measuring the load and it was calculated by using the equation,

$$f_c = P/A,$$

where, f_c = Compressive Strength,

P = Load,

A = Area of the cube.

Compressive strength of concrete cubes was measured at the age of 7, 14 and 28 days are shown in Table IV.

SEEK DIGITAL LIBRARY

TABLE IV RESULTS OF COMPRESSIVE STRENGTH

Type of concrete	Compressive strength N/mm^2		
	7 days	*14 days*	*28 days*
C.C [CC1]	35.4	39	48.5
C.C with fly ash [CC2]	30.4	36.2	55.2
C.C with silica fume [CC3]	29.2	35.1	54.4
C.C with fly ash and silica fume [CC4]	27.1	33	56.8
C.C with fly ash, silica fume and RFRC [CC5]	23	28.2	51.3
C.C with fly ash, silica fume and PPFRC [CC6]	21.2	26.3	49.1
C.C with fly ash, silica fume and Hybrid [CC7]	22.6	29.8	50.6

Note:

- CC – Conventional Concrete
- RFRC – Recron3s Fiber Reinforced Concrete
- PPFRC – Polypropylene Fiber Reinforced Concrete
- Hybrid – Both Recron3s and Polypropylene fibers

The comparative results for compressive strength of concrete cube between Conventional concrete, Recron3s fiber reinforced concrete, Polypropylene fiber reinforced concrete, and hybrid polypropylene and Recron3s fiber specimens are shown in Figure 4.

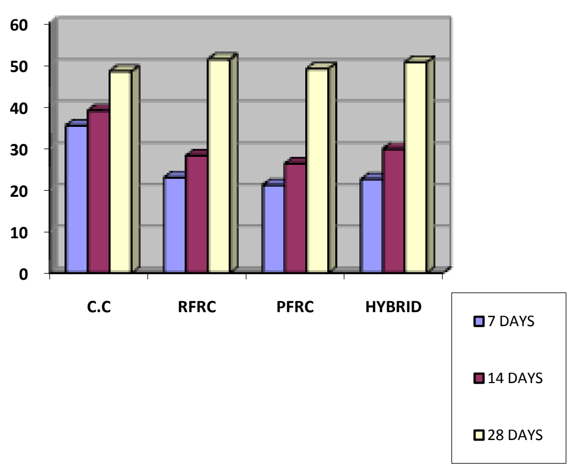

Figure 4 Variation of compressive strength at different ages.

There was an increase in the compressive strength of cubes produced with recron3s fibers and polypropylene fibers. The presence of fly ash, when compared with plain concrete, increased the average compressive strength. It is observed that recron3s fibers and polypropylene fibers did not recover the compressive strength loss of fly ash. The presence of fly ash, silica fume when compared with plain concrete, increased the average compressive strength. It is evident from Table IV that the compressive strength of recron3s fiber and hybrid with fly ash, silica fume concrete continued to increase with the age.

Split Tensile Strength

Three specimens of cylindrical shape of diameter 150 mm and length 300 mm were tested under a compression testing machine of 2000 KN capacity under a compressive load across the diameter along its length till the cylinder splits (Figure 5). Split tensile strength of concrete cubes was measured at the age of 7 and 28 days. The tension develops in a direction at right angles to the line of action of the applied load.

Figure 5 Variation of split tensile strength at different ages

The split tensile strength was calculated as follows:

Split tensile strength (MPa) = $2P / \pi DL$

Where, P = Failure load,

L = Length of cylinder,

D = Diameter of cylinder

The results show that in general, there is an increase in splitting tensile strength of cylinder concrete specimens with the addition of fibers in different mix to the concrete at the age of 28 days.

SEEK DIGITAL LIBRARY

TABLE V RESULTS OF SPLIT TENSILE STRENGTH

Mix	Split Tensile Strength N/mm^2		
	7 days	*14 days*	*28 days*
C1	3.01	3.36	4.38
C2	2.93	3.19	4.82
C3	3.37	3.96	5.03
C4	3.09	3.55	5.18
C5	3.11	3.73	5.09

Note:
C1- Conventional Concrete
C2- Conventional Concrete with fly ash and silica fume
C3- Conventional Concrete with fly ash, silica fume and RFRC
C4- Conventional Concrete with fly ash, silica fume and PPFRC
C5- Conventional Concrete with fly ash, silica fume and Hybrid

The comparative results for split tensile strength of concrete cylinder of conventional concrete, Recron3s fiber reinforced concrete, Polypropylene fiber reinforced concrete, and hybrid [Polypropylene and Recron3s] fiber specimens are shown in Figure 6.

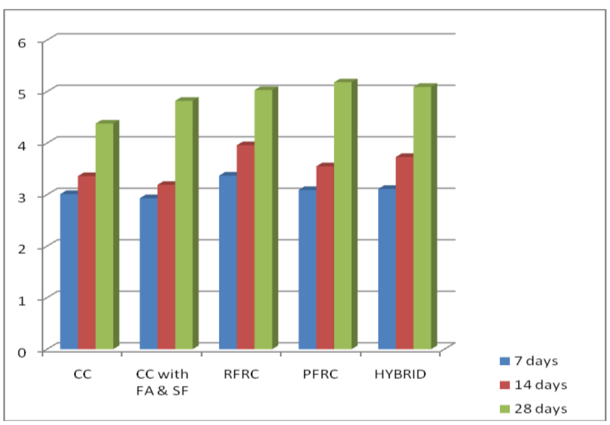

Figure 6 Variation of split tensile strength at different ages.

Results and Discussion

A. Compressive strength

At 28 days, conventional concrete,CC1 (0 % admixture and 0% fiber) achieved compressive strength of 48.5 MPa even as other mixes CC2,CC3,CC4,CC5,CC6, and CC7 achieved compressive strength of 55.2, 54.4, 56.8, 51.3, 49.1 and 50.6 MPa, respectively as shown in Table IV. In comparison with conventional concrete, recron3s fibers added mix has marginally improved the compressive strength at 28 days. The addition of polypropylene fibers to the concrete mix improves the compressive strength but not greater than that obtained from the recron3s fiber mix.

B. Split tensile strength

From the Table V, split tensile strength at 28 days of conventional concrete C1 was 4.38 MPa. The other mixes C2, C3, C4 and C5 achieved split strength of 4.82, 5.03, 5.18 and 5.09 MPa respectively in comparison with C1 concrete mix. Split tensile strength increased in C2, C3, C4, and C5 mixes owing to addition of fibers and mineral admixtures.

Conclusion

The addition of polypropylene fibers, recron3s fibers into the fly ash and silica fume in different concrete mixes marginally improve the compressive strength at 28 days. The minimum percentage of fly ash and silica fume were added in concrete so that the performance of the concrete increases. There is an increase from 3% to 9% in split tensile strength for all fiber mixes when compared with that of control mix. The volume fraction of hybrid fiber concrete mix gives better strength values on par with control mix. The recron3s fiber, polypropylene fiber (Boasee fiber), admixtures are used in concrete to give more compressive strength, split tensile strength when compared to that of nominal concrete.

REFERENCES

[1] ACI Committee 544 Guide for specifying, mixing, placing and finishing steel fibre reinforced concrete, Journal of the American Concrete Institute, Mar – Apr 1984, pp. 140-147.
[2] ACI Committee 544 "Measurement of properties of fibre reinforced concrete", Reported by American Institute-Journal July 1978, pp. 283-289.
[3] Fanella, D.A. and Naaman, A.E., "Strain properties of Fibre reinforced mortar in compression" American Concrete Institute Journal, Jul-Aug, 1985, pp. 475 – 482.
[4] Jagannathan.A , "Impact characteristics of Hybrid Fibre Reinforced Cementitious Matrix" Civil Engineering & Construction Review, January 2009, pp. 58- 66.
[5] Patodi, S. C. and Kulkarni, C. V., (2012), "Performance evaluation of hybrid fiber reinforced concrete matrix,"International Journal of Engineering Research and Applications (IJERA), vol. 2, Issue 5, September-October, pp.1856-1863.
[6] Soroushian, 1991 "Fibre – type effects on the performance of Steel Fibre Reinforced Concrete" ACI Material Journal, March – April 1991, pp. 129-134.
[7] Srinivasa Rao, P Seshadri Sekhar. T and P. Sravana, "Durability Studies on Glass Fibre SCC" Indian Concrete Journal, October 2009, pp. 44-52
[8] Vikrant, S Vairgade Kavita S. Kene, (2012), "Experimental investigation on hybrid fiber reinforced concrete" International Journal of Engineering Research and Applications (IJERA), vol. 2, Issue 3, May- June, pp. 1037-1041.

SEEK DIGITAL LIBRARY