International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-2, December 2018

Study of Performance of Steel and Polypropylene Fiber Reinforced Concrete

Arti M. Sorte, A. N. Burile, K. V. Madurwar

Abstract: ***In this paper, we studied the performance of fiber reinforced concrete (FRC) with steel and polypropylene fibers. Here M 40 grade of concrete reinforced with different percentage of steel and polypropylene fibers was experimentally investigated for the compressive strength and tensile strength of FRC. The percentage variation of steel fiber is taken as 0.5%, 1.0% and 1.5% by volume of concrete for steel fiber reinforced concrete (SFRC). The percentage variation of polypropylene fiber is taken as 0.1%, 0.2% and 0.3% by volume of concrete for polypropylene fiber reinforced concrete (PPFRC).The practical results obtained has been studied and analyzed by comparing it with a control sample specimen (0% fiber). The relationship of compressive strength, tensile strength vs. percentage of fiber, has been represented graphically. Observations clearly shows the significant improvement in 28 and 45 days compressive strength and tensile strength for M 40 grade of concrete on addition of fibers along with enhanced properties of fiber reinforced concrete.***

Keywords: Compressive Strength, Polypropylene Fibers, Reinforced Concrete, Steel Fibers, Split Tensile Strength.

I. INTRODUCTION

Cement concrete is the most widely used construction material within the world as it provides good compressive strength, workability and increases the life of structures. However, researcher has been know since 1800's, that concrete is weak in tension and results in sudden tensile failure without warning due to its brittle behavior[1]. But, plain concrete is less ductile with low tensile strength, and low resistance to cracking. Due to presence of internal micro cracks in the concrete, its tensile strength get reduced leading to brittle fracture of the concrete[2]. Generally, members of concrete are provided with reinforcing bars to overcome the tensile stresses and lack of ductility and strength. It is required to provide continuous reinforcing steels at specified location to optimize its performance [3]. Though the steel reinforcement in concrete probably increases its strength, but to produce a concrete with essential tensile strength and better crack resisting property, fibers are found to be more effective[4]. Fiber is a small in size made from reinforcing material and possess certain required characteristic properties [5].

Manuscript published on 30 December 2018.
***** Correspondence Author (s)

A. M. Sorte, Assistant Professor, Department of Civil Engineering, Priyadarshini Bhagwati college of Engineering, RTMNU, Nagpur (MH), India.

A. N. Burile, Assistant Professor, Department of Civil Engineering, Priyadarshini Bhagwati college of Engineering, RTMNU, Nagpur (MH), India.

K. V. Madurwar, Assistant Professor, Department of Civil Engineering, Priyadarshini Bhagwati college of Engineering, RTMNU, Nagpur (MH), India.

It has been identified that the addition of small sized, uniformly spread fibers in concrete would help to reduce chances of failure of structure due to cracking, and simultaneously upgrade its static and dynamic properties [6]. Thus, fiber reinforced concrete can be defined as the concrete having fibrous material which is used to enhance its structural integrity by increasing toughness and crack resistant characteristics[7].

Fiber reinforced concrete (FRC) can be consider as a composite materials made by mixing cement, jellies, with discrete discontinuous fibers[8]. The function of these fibers is to form link throughout the cracks that develop ductility during post- cracking phase helps to bear comparatively large stresses[9].

Hamid Reza Chaboki et al, studied the ductility ratio and flexural behavior of reinforced concrete beams by incorporating steel fibers with coarse recycled aggregate where they observed that the effect of steel fibers depends on spacing of transverse reinforcement and recycled aggregates effect depend on the quantity of steel fibers and spacing of transverse reinforcement both[10].

Though the structural strength of Reinforced concrete depends on bonding between steel reinforced and concrete but it will get affected at high temperatures. Investigations showed that with steel and polypropylene fibers and with high aspect ratio, when concrete was exposed to temperature of 450 °C, it looses its bond strength[11]. In his investigation found that at temperatures higher than 650 °C, with higher aspect ratio,the use of steel fibers reduces the ductility of structure due to the loosening of steel fibers bond with matrix[12].

When we apply short and discrete fibers as a reinforcement in the concrete matrix, they behave effectively as solid inclusions.Though the steel fiber reinforcement in fiber concrete cannot be directly replaced by main reinforcement in structural members but it enhance the resistance of conventionally reinforced structural members to deflection, cracking also[13].

It was found that width of cracks with SFRC are much smaller than only reinforced concrete.SFRC can bear maximum stresses with controlled crack width hence improve the serviceability of structures. Joshua A.et al concluded that span of slab can be increased without adding any extra reinforcement[14]. Chandra Sekhar Das et al, observed that the addition of fiber content exhibit negligible effects on compressive strength but it impart tensile and flexural strength to the concrete[15]. Ali Mardani Aghabaglou et al. found that 0.8% of polypropylene fibers provides good durability and dimensional stability to the structure and above that the mixture was non uniform, non homogeneous with the increase in voids ratio[16].

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

Comparing to conventional concrete, SFRC mixes contain higher cement proportions and higher ratios of fine to coarse aggregate hence the mix design procedures for SFRC are different than the ordinary one[17]. The workability of the mix depend on fiber type, size, percentage of fibers, and orientation. It was observed to be reduced with the amount and size of aggregate particles higher than 5 mm increased[18].

Aspect ratio is given as the ratio of length of fiber to its diameter. The normally for steel fiber it ranges from 20 to 100. Aspect ratio of steel fiber more than 100 is not favored, due to its inconsiderable workability, mat formation in the mix and also uneven mixing of fiber in the concrete. To avoid any bleeding, segregation and to improve the workability, less amount of water should be uses[19]. Aspect ratio of the fibers is an other factor which affect the workability. With increasing aspect ratio,the workability decreases [20].

In general, the difficulties regarding uniform distribution of fibers, and adequate workability are more common with the increase in length and volume of fibers which takes place due to their clumping with each other[21].

Sharath M. Y. et al Suggested that to eliminate the problem of clumping, the fibers should be added either to the wet concrete at last or to the fine jellies during the addition of aggregate on a conveyor belt. Also greater care should be taken while adding water to SFRC, as w/c ratio of above 0.5 increases the slump of the SFRC without increasing its workability [21]. BiaoLi et al. concluded that flexural strengths, toughness, deflection of concrete improved with the addition of fiber and increasing aspect ratio. Hook-end steel fibers form good bond with concrete to sustain large amount of loads [22].

The most common applications of SFRC over the past thirty years in various fields of civil engineering are widespread such as for pavements and slabs, tunnel linings, bridge deck, airport pavements, shotcrete containing silica fume etc . The fibers comparatively expensive which increases the initial cost of construction; this restrict the use of SFRC to distinct functions[23].

II. MATERIALS AND METHODOLOGY

A. Materials Used and Their Properties

The materials used are cement, sand, coarse aggregate, steel fibers, polypropylene fibers and water.

Cement- Ordinary Portland Cement 43 grade ULTRATECH cement is used in this experimental work confirming to IS 8112-2013 [24] with Fineness- 2.66%, Specific Gravity-3.15, Initial setting time- 110min., Final setting time-244min, Consistency- 32%, Soundness- 7mm, Compressive Strength 28 days- 47.94N/mm^2.

Fine aggregates- Locally available, sand passing through 4.75 mm IS Sieve was used confirming to IS 383-1970 [25], under Zone I with Specific Gravity- 2.48, Water Absorption-0.42%, Fineness Modulus- 3.15.

Coarse aggregates- Maximum sizes of 20mm conforming to IS 383-1970, with Specific Gravity- 2.88, Water absorption- 0.5, Fineness modulus -7.26, Flakiness index -27%, Impact value-15.27%, Crushing value -18%, angular in shape.

Water -Potable water

Fibers-

***a) Steel fibers*:-** The mild steel, hooked end fibers having diameter-0.65mm, Length-35mm, Aspect Ratio-53.85, Density-7850kg/m^3. These fibers are made by STEWOLS INDIA PVT. LTD. Nagpur, Maharashtra, India.

***b) Polypropylene fibers (pp)*:** fine polypropylene monofilaments, supplied by Reliance Industry called as RECRON 3s , three different sizes i.e. 6 mm, 12 mm and 24 mm., Length of fiber-24mm and density 900kg/m^3.

B. Methodology

The experimental procedure consists of preparation of fiber reinforced concrete with different percentage (by volume of concrete) of fibers. In this work M40 mix was used with the mix ratio 1:1.5:2.74 as per standards (IS10262:2009 & IS456:2000)[26,27]. The details of the mix proportioning of materials and quantity of fibers required are shown in the table1and 2.For every mix steel fibers are added by volume of cement from 0 % to 1.5% at increasing rate of 0.5%. And polypropylene fibers from 0 % to 0.3% at increasing rate of 0.1%. The variety of cubes and cylinder specimens were casted as per requirements of tests and as per code of practices. The compressive strength and split tensile strength tests were conducted after 28 days and 45 days of curing on sample specimen. Their results are shown in the below tables and histograms.

Table 1. Mix Proportions

Material	Quantity(kg/m^3)	Proportion
Cement	428	1
Sand	645	1.5
Coarse Aggregate (20mm and down)	1172	2.74
Water	197	0.46 (W/C ratio)

Table 2. Quantity of fibers

S.N.	Steel fiber Quantity		Polypropylene fiber Quantity	
	% of fibers	Weight of fibers (gm)	% of fibers	Weight of fibers (gm)
1.	0.5	1375	0.1	31.5
2.	1.0	2750	0.2	63
3.	1.5	2063	0.3	94.5

C. Experimental Program

For studying the performance and effect of addition of Steel fibers (hooked end) and Polypropylene fibers in concrete, 42 cubes and 42 cylinders were casted , where each cube of size 15cm × 15cm × 15cm was tested for compressive strength, and 10cm × 20cm (height) cylinders were tested for split tensile strength. Required quantities of the ingredients for casting of cubes and cylinders were accurately weighed with the help of a weighing machine nearest to one gram by weigh batching system. Ingredients were mixed in a laboratory by using batch mixer with a mixing capacity of 35 litre. Following procedure was adopted for mixing of ingredients;

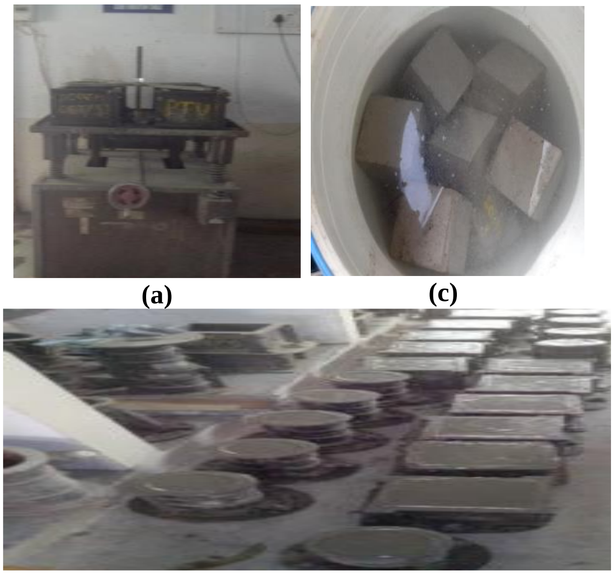
Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

1) Dry mixing of the cement and aggregates was done for a minute.
2) fibers were added gradually and further dry mixing was done for a minute.
3) Water was added gradually to the dry mix and the final mixing was done for a duration of four minutes to ensure that the resulting concrete is uniform in appearance and cohesive along with uniform distribution of fibers throughout the concrete. Thus the total time of mixing was six minutes.

Casting and compaction of the concrete specimen was done according to IS: 516-1959[28]. Curing of the test specimen was done according to IS: 516-1959 by immersion in curing tanks.

(a) (b)

Fig.1 Mixing of fibers- (a)Steel fibers (b) Polypropylene fibers.



(a) (c)

(b)

Fig. 2. Casting and Curing of concrete samples (a)Compaction (Table Vibration) (b) Moulding (c) Curing of specimens.

D. Testing of Specimen

a) Slump Test

Slump test was carried out according to IS: 1199-1959 in laboratory to determine the workability of concrete. The mould available was just like a frustum of a cone with the inner dimensions: bottom diameter = 20cm, top diameter =10cm and height = 30cm.

After placing the mould on a plane, horizontal, and non-absorbent surface, it was filled with concrete in four levels, where each level was nearly ¼ th of the moulds height. Then by tamping each level by giving 25 strokes, top layer was been rodded, so that the mould is exactly filled. Then by removing mould from the concrete quickly by raising it slowly and carefully in proper direction, slump was calculated.

Fig. 3. Slump Test Apparatus

b) Compressive Strength Test (ASTM C 39/C39M)

The compressive strength test was carried out on the casted cubes. After 24 hours of casting, the cube specimen were demoulded and were taken for curing for 28 days and 45 days. After curing, these cubes were tested by Compression Testing Machine (CTM) (capacity 2000 KN) as per IS:516-1959[22].The load at failure of each cube was noted. For every proportion of fibers, three cubes were tested and their average value was calculated. The compressive strength was calculated by dividing maximum load at failure with cross sectional area of cube.

Fig.4. Compressive strength test of Cube.

Fig.5. Failure of Cube

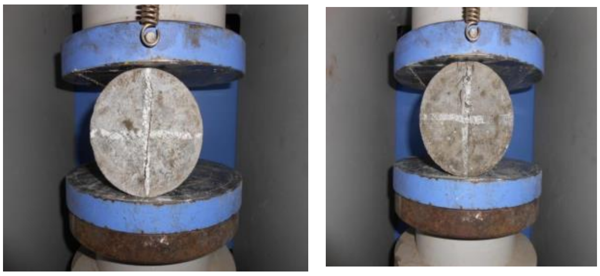
c) Split Tensile Strength Test

The split tensile strength test was conducted as per IS 5816:1999[29]. For conducting this test, cylinder specimens with 100 mm diameter and length of 200mm were casted. After 24 hours of casting, the specimen were demoulded and then taken for 28 days and 45 days curing. The test was conducted using CTM by applying a compressive load across the diameter of cylinder till the it splits as shown in figure. The failure load was recorded. Again similar to the cube , for every proportion of fibers, three cylinders were tested and their average value was calculated. Formula used for Split tensile strength was :Split Tensile strength (MPa) = $2P / \pi DL$

Where, P is failure load, D and L are diameter and length of cylinder respectively.

Fig.5. Split tensile Strength Testing of Cylinder.

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)



(a) (b)

Fig.6. Crack formation in cylinder. (a) Control specimen (b) Specimen with FRC.

III. EXPERIMENTAL RESULTS

Slump tests results for SFRC and PPFRC are shown in table 3 and 4.

A. Slump Test Results:

Table 3. Slump Test Results of Steel FRC

% of Steel fiber	0	0.5	1	1.5
Slump (mm)	80	50	31	17

Table 4. Slump Test Results of Polypropylene FRC

% of Polypropylene fiber	0.0	0.1	0.2	0.3
Slump (mm)	80	28	17	12

B. Compressive Strength Test Results:

Table 5. Compressive Strength Test of SFRC at 28 days and 45 days.

Mix Type (Steel fibers %)	Failure Load (KN)	28 days Compressive strength (MPa)		Failure Load (KN)	45 days Compressive strength (MPa)	
		Load/ Area	Avg.		Load/ Area	Avg.
S1 (0.0%)	1146	50.93		1207	53.64	
S2 (0.0%)	1010	44.88	48.42	1148	51.02	52.44
S3(0.0%)	1113	49.46		1185	52.66	
S4 (0.5%)	1258	55.91		1302	57.86	
S5 (0.5%)	1180	52.44	55.12	1362	60.53	59.07
S6(0.5%)	1283	57.02		1324	58.84	
S7 (1.0%)	1386	61.6		1511	67.15	
S8(1.0%)	1495	66.44	64.63	1535	68.22	67.31
S9(1.0%)	1482	65.867		1498	66.57	
S10 (1.5%)	1347	60.756		1463	65.02	
S11 (1.5%)	1360	60.44	60.26	1419	63.06	64.24
S12 (1.5%)	1341	59.6		1455	64.66	

Table 6. Compressive Strength Test of Polypropylene FRC 28 days and 45 days.

Mix Type (Steel fibers %)	Failure Load (KN)	28 days Compressive strength (MPa)		Failure Load (KN)	45 days Compressive strength (MPa)	
		Load/ Area	Avg.		Load/ Area	Avg.
S1 (0.0%)	1146	50.93		1207	53.64	
S2 (0.0%)	1010	44.88	48.42	1148	51.02	52.44
S3(0.0%)	1113	49.46		1185	52.66	
S13 (0.1%)	1253	55.689		1308	58.13	
S14 (0.1%)	1228	54.578	55.30	1336	59.37	58.67
S15 (0.1%)	1252	55.644		1317	58.53	
S16 (0.2%)	1256	55.82		1312	58.31	
S17 (0.2%)	1290	57.33	56.94	1324	58.84	59.31
S18 (0.2%)	1298	57.68		1368	60.8	
S19 (0.3%)	1304	57.95		1371	60.93	
S20 (0.3%)	1320	58.66	58.07	1388	61.68	61
S21 (0.3%)	1296	57.6		1359	60.4	

C. Split Tensile Strength Test Results:

Table 7. Split Tensile Strength Test Results of Steel FRC at 28 days and45 days .

Mix Type (Steel Fibers %)	Failure Load (KN)	28 days Tensile Strength (MPa)		Failure Load (KN)	45 days Tensile Strength (MPa)	
		Load/ Area	Avg.		Load/ Area	Avg.
S1 (0.0%)	93.2	2.96		104.6	3.33	
S2 (0.0%)	101.9	3.24	3.11	98.4	3.12	3.22
S3(0.0%)	97.6	3.10		101.4	3.22	
S4 (0.5%)	138.8	4.418		148.5	4.72	
S5 (0.5%)	139.0	4.424	4.486	140	4.45	4.62
S6(0.5%)	148.0	4.618		147.8	4.70	
S7 (1.0%)	178.2	5.672		180.2	5.73	
S8(1.0%)	170.5	5.42	5.55	175.8	5.59	5.67
S9(1.0%)	175.1	5.573		178.7	5.69	
S10 (1.5%)	177.1	5.63		185	5.88	
S11 (1.5%)	173.2	5.51	5.63	186.1	5.92	5.86
S12 (1.5%)	181.3	5.77		182.4	5.80	

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-2, December 2018

Table 8. Split Tensile Strength Test Results of Polypropylene FRC at 28 days and45 days

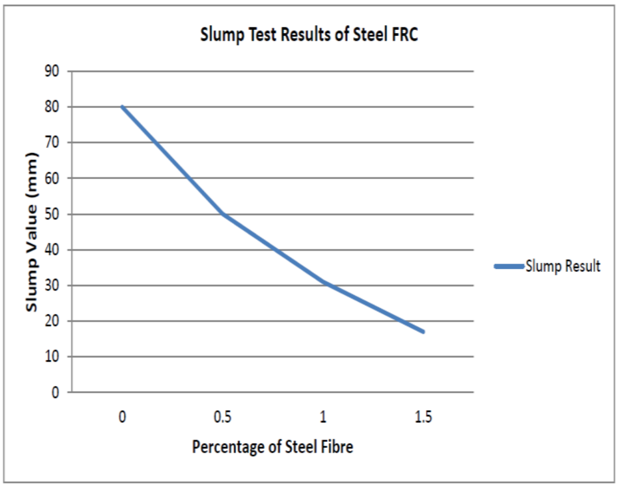
Mix Type (Steel fibers %)	Failure Load (KN)	28 days Tensile Strength (MPa)		Failure Load (KN)	45 days Tensile Strength (MPa)	
		Load/Area	Avg.		Load/ Area	Avg.
S1 (0.0%)	93.2	2.96		104.6	3.33	
S2 (0.0%)	101.9	3.24	3.11	98.4	3.12	3.22
S3 (0.0%)	97.6	3.10		101.4	3.22	
S13 (0.1%)	116.7	3.71		116.7	3.86	
S14 (0.1%)	113.5	3.61	3.58	113.5	3.79	3.76
S15 (0.1%)	109.8	3.49		109.8	3.63	
S16 (0.2%)	118.1	3.76		121.6	3.87	
S17 (0.2%)	121.4	3.85	3.75	123.5	3.93	3.87
S18 (0.2%)	114.6	3.65		119.4	3.80	
S19 (0.3%)	124.9	3.97		132	4.20	
S20 (0.3%)	117.7	3.74	3.84	120.4	3.83	3.98
S21 (0.3%)	120.3	3.83		122.5	3.90	

Fig. 7. SFRC Matrix Binded by Fibers

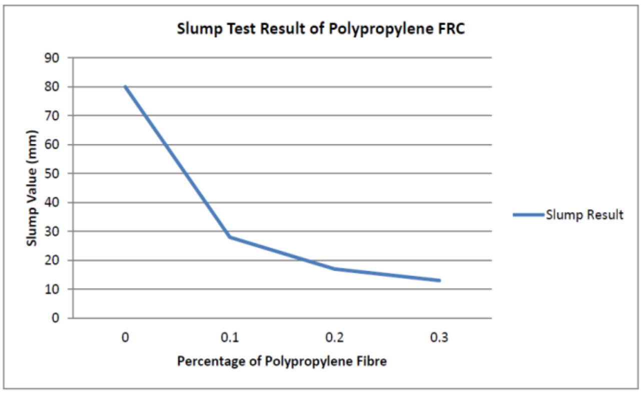
Fig. 8. Control Specimen Splits in Exactly Two Parts

D. Graphical Representation of Results

a) Slump Test Results:

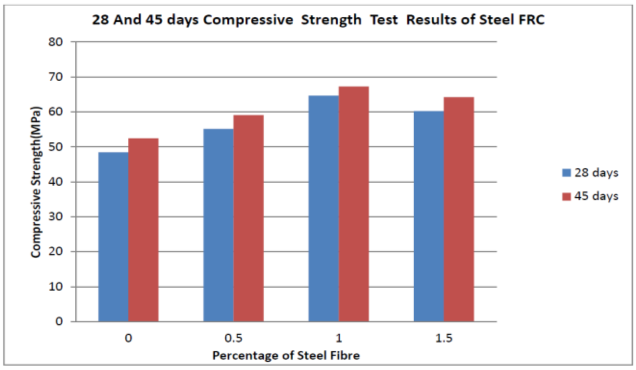


Graph 1: Slump Test Results of Steel FRC

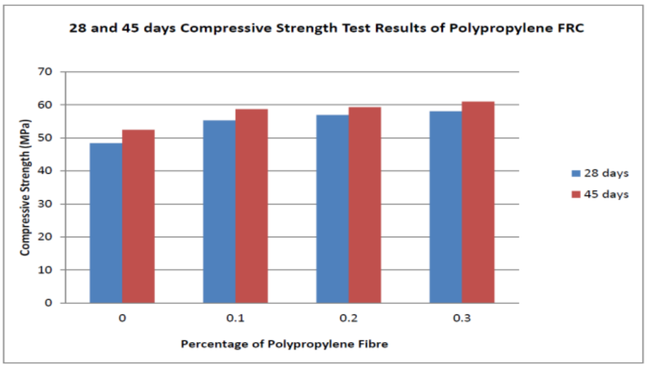


Graph 2: Slump Test Result of Polypropylene FRC

b) Compressive Strength Test Results

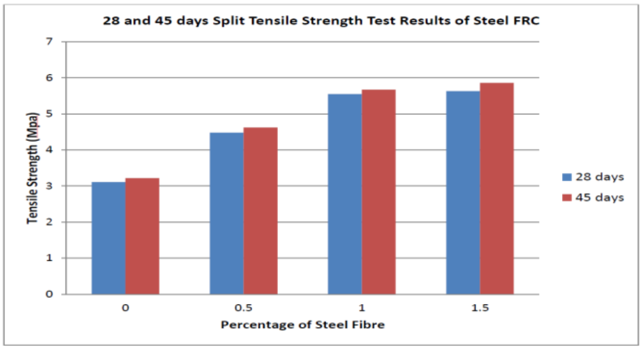


Graph 3: 28 and 45 days compressive strength test results of Steel FRC.



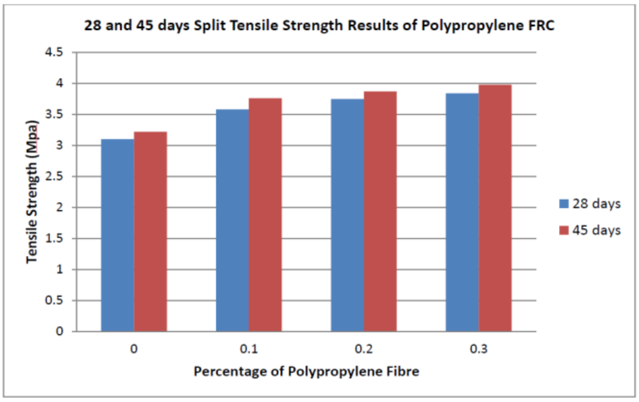
Graph 4: 28 and 45 days compressive strength test results of Polypropylene FRC

c) Split Tensile Strength Test Results



Graph 5: 28 and 45 days split tensile strength test results of Steel FRC

*Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)*



Graph 6: 28 and 45 days split tensile strength results of Polypropylene FRC.

IV. CONCLUSION AND FUTURE SCOPE

A. Conclusion

Based on of the present experimental investigation on study on 'Performance of Steel and Polypropylene fiber Reinforced Concrete', we concluded that:

1. Workability of the fiber reinforced concrete improved by incorporation of steel as well as polypropylene fibers. From graph 1 and 2, Slump values were observed lower in the case of polypropylene fibers as compared to the steel fibers.
2. The compressive strength of the fiber reinforced concrete was increased with the increase in percentage by volume of steel as well as polypropylene fibers (refereing graph 3 and 4).
3. Maximum value of compressive strength was observed at 1.0% for steel fibers and 0.3% for polypropylene fibers.
4. The tensile strength of fiber reinforced concrete was increased with the increase in percentage by volume of steel as well as polypropylene fibers.
5. Maximum value of tensile strength was observed at 1.5% for steel fibers and 0.3% for polypropylene fibers.
6. It was identified that with 1% dosage of steel fiber, the compressive strength and tensile strength of fiber reinforced concrete was significantly increased. At a higher dosage of steel fibers the tensile strength increased slightly. Hence, the optimum dosage of steel fiber was observed as 1%.
7. As compared to the control specimen (0 % fibers), crack formation was observed to be lesser in the fiber reinforced concrete (refer fig 6(a) and(b)) .

B. Future Scope

1. For development rational design procedures to incorporate the properties of steel-fiber reinforced concrete in various structures.
2. Analysis of ductility characteristics of SFRC for potential to use in earthquake resistant design & construction.
3. Investigation of mechanical and physical properties of SFRC at low temperatures.
4. Analysis of various properties of SFRC using high strength matrix.
5. Analysis of the impact of steel fibers on plastic and drying shrinkage of concrete.
6. Analysis of coatings for steel fibers to modify bond with the matrix and to provide corrosion protection.
7. Investigation of the use of steel-fibers in hydraulic non Portland cement concrete.
8. Develop standardized test procedures for impact and fatigue loading to demonstrate performance differences among various fiber types.

RFERENCES

1. Hamid Pesaran Behbahani, Behzad Nematollahi, Majid Farasatpour, "Steel Fiber Reinforced Concrete: A Review" Conference: Proceedings of the International Conference on Structural Engineering Construction and Management , At Kandy, Sri Lanka, 2011.
2. Milind V. Mohod , "Performance of Steel Fiber Reinforced Concrete" , Journal of Mechanical and Civil Engineering, Vol. 12, Iss.1, PP 28-36, 2015, DOI: 10.9790/1684-12112836.
3. Reeta, Manoj, Karandeep, Mr. Amit Singhal, "Fiber Reinforced Concrete", Int. Journal of All Research Education and Scientific Methods (IJARESM), Volume 4, Issue 7,pp155-160, 2016.
4. Ragavendra S., Praveen Reddy, Dr. Archanaa Dongre "fiber reinforced concrete- a case studys". 33rd national Convention of Architectural Engineers and National Seminar on 'Architectural Engineering Aspect for sustainable building envelopes' ArchEn-BuildEn-2017, by Institution of Engineers India in Association with Indian Association of structural Engineers, At Institution of Engineers, Khairatabad, Hyderabad.
5. Project synopsis on "Effect of blast furnace slag on strength of gi fiber reinforced polymer concrete", Posted 19th February 2013 by kumar mayank. (http://itskumar-mayank.blogspot.com/)
6. Muhammad Akram Akhund, Abdullah Sannd, Uroosa Memon, Shamotra Jai Oad, "Utilization of Soft Drink Tins as Fiber Reinforcement in concrete", Engineering science and technology international research journal, vol.1, issu. 2, pp 47-52, 2017.
7. https://www.quora.com/What-is-fiber-reinforced-concrete.
8. Nitin Kumar, Sangeeta "A Review study on use of Steel Fiber as Reinforcement Material with Concrete", Journal of Mechanical and Civil Engineering, Volume 12, Issue 4, PP 95-98, 2015, DOI: 10.9790/1684-12439598.
9. A.R.Pradeep , M.I.Basava, lingana Gowda "A Case Study on Strength Properties of Partially Replaced Recycled Aggregate and Steel Fibers to A Nominal Concrete" Journal of Mechanical and Civil Engineering,Volume 13, Issue 3, PP 52-58, 2016, DOI: 10.9790/1684-1303075258.
10. Hamid Reza Chaboki, Mansour Ghalehnovi, Arash Karimipour, Jorgede Brito,"Experimental study on the flexural behaviour and ductility ratio of steel fibers coarse recycled aggregate concrete beams", Construction and Building Materials,Volume 186, Pages 400-422, 2018, https://doi.org/10.1016/j.conbuildmat.2018.07.132.
11. F.B.Varona, F.J.Baeza, D.Bru, S.Ivorra,"Evolution of the bond strength between reinforcing steel and fiber reinforced concrete after high temperature exposure" J. of Construction and Building Materials,Volume 176, 10 July 2018, Pages 359-370, https://doi.org/10.1016/j.conbuildmat.2018.05.065.
12. F. B. Varona, F. J. Baeza, D.Bru, S. Ivorra, "Influence of high temperature on the mechanical properties of hybrid fiber reinforced normal and high strength concrete", Construction and Building Materials, Volume 159, Pages 73-82, 20 January 2018. https://doi.org/10.1016/j.conbuildmat.2017.10.129.
13. Prof. Priti A. Patel "Improvement of Shear Strength using Triangular Shape fiber in Concrete" , NBM&CW, a civil engg magzine, Aug 2010.
14. Joshua A.McMahon, Anna C. Birely, "Service performance of steel fiber reinforced concrete (SFRC) slabs" Engineering Structures, Volume 168, Pages 58-68, 2018. https://doi.org/10.1016/j.engstruct.2018.04.067.
15. ChandraSekhar Das, Tanish Dey, Ramkrishna Dandapat, Bibhuti Bhusan Mukharjee, Jitendrakumar, "Performance evaluation of polypropylene fiber reinforced recycled aggregate concrete", Construction and Building Materials, Volume 189, Pages 649-659, 2018, https://doi.org/10.1016/j.conbuildmat.2018.09.036.
16. Ali Mardani Aghabaglou, Suleyman Ozen, and Muhammet Gokhan Altun, "Durability performance and dimensional stability of polypropylene fiber reinforced concrete", Journal of Green Building, Vol. 13, No. 2, pp. 20-41, 2018. https://doi.org/10.3992/1943-4618.13.2.20.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

17. Mohammed S. Imbabi, Collette Carrigan, Sean McKenna, “Trends and developments in green cement and concrete technology”, International Journal of Sustainable Built Environment, vol. 1, pp-194–216, 2012, DOI: 10.1016/j.ijsbe.2013.05.001.
18. Abdul Ahad, Zishan Raza Khan, Shumank Deep Srivastava, “Application of Steel Fiber in Increasing the Strength, Life-Period and Reducing Overall Cost of Road Construction by Minimizing the Thickness of Pavement” World Journal of Engineering and Technology,vol 3, 240-250, 2015, http://dx.doi.org/10.4236/wjet.2015.34025.
19. Rui D. Neves and Joao C. O. Fernandes de Almeida, “Compressive behaviour of steel fiber reinforced concrete”, structural concrete, pp 1464-4177, 2005.
20. BOOK-fiber Reinforced Cementitious Composites, Second Edition By Arnon Bentur, Sidney Mindess, ch steel fibers, pp 273.
21. Sharath M. Y., Sanjith J., Manjunath H. R. “Experimental Investigation on Steel Fiber Reinforced Concrete” International Journal of Scientific Development and Research,Volume 2, Issue 6, pp-204-210, 2017.
22. BiaoLi,LihuaXu,YuchuanShi,YinChi,QiLiu, ChangingLi , “Effects of fiber type, volume fraction and aspect ratio on the flexural and acoustic emission behaviors of steel fiber reinforced concrete”,Construction and Building Materials, Volume 181, Pages 474-486, 2018. https://doi.org/10.1016/j.conbuildmat.2018.06.065.
23. https://www.seminarsonly.com/Civil_Engineering/Polymer_Modified_Steel_fiber_Reinforced_Concrete.php, Published on Feb 14, 2016.
24. IS 8112:2013, 43 Grade Ordinary Portland Cement – Specification (First Revision), Bureau of Indian Standards, New Delhi, India, 1989.
25. IS 383:1970, Specification for coarse and fine aggregates from natural sources for concrete (second revision), Bureau of Indian standards, New Delhi, India, 1970.
26. IS 456-2000, Code of Practice for Plain and Reinforced Concrete, Bureau of Indian Standards, New Delhi, India, 2000.
27. IS 10262-2009, Recommended Guidelines for Concrete Mix Design, Bureau of Indian Standards, New Delhi, India, 2009.
28. IS: 516-1959, Indian standard methods of tests for strength of concrete, Bureau of Indian Standards, New Delhi, India, 1959.
29. IS 5816-1999, Method of Test for Splitting Tensile Strength of Concrete., Bureau of Indian Standards, New Delhi, India, 1999.

Author Profile:

Ms. Arti. M. Sorte, I have passed my B. E in civil engineering from RTMNU, Nagpur. I have completed my M-tech in Environmental Engineering from RTMNU, Nagpur and currently working as a Asst. Professor in department of Civil Engineering, Priyadarshini Bhagwati College of Engineering, Nagpur, RTMNU, Maharashtra, India (440009). I have also register for Ph.D. My field of interest are environmental engineering, waste materials and their productive uses. Work Experience: Teaching -10 years, I have published 5 papers in international journals and 2 in international conferences. I am also having membership of professional bodies like Indian Society of Technical Education (ISTE), IAENG, IRED.

Mr. A. N. Burile, I have passed my B.E in Civil Engineering from RTMNU, Nagpur. I have completed my M-tech in Environmental Engineering from RTMNU, Nagpur and currently working as a Asst. Professor in department of Civil Engineering, Priyadarshini Bhagwati College of Engineering, Nagpur, RTMNU, Maharashtra, India (440009). I have pass Ph.D. Entrance Test of RTMNU, Nagpur. I am interest to work on agro-waste and agro-industrial waste. My total work experience is 15 years, I have published 5 papers in International Journals, 1 in international conferences and 5 in national conferences. I am also having membership of professional bodies like Indian Concrete Institute (ICI), Indian Society of Technical Education (ISTE), Institute of Engineers (IEI),

Mr. K. V. Madurwar, I have passed my B.E in civil engineering from RTMNU, Nagpur. I have completed my M-tech in Geotechnical Engineering from RTMNU, Nagpur and currently working as a Asst. Professor in department of Civil Engineering, Priyadarshini Bhagwati College of Engineering, Nagpur, RTMNU, Maharashtra, India(440009).I have also register for Ph.D. My field of interest are sustainable infrastructure development by use of waster/refuse materials from industrial and agro-industrial waste. Work Experience: 17 years, I have published 6 papers in International Journals and 1 in international conferences. I am also having membership of professional bodies like Indian Geotechnical Society(IGS), Indian Concrete Institute(ICI), Institute of Engineers(IEI),

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)