Impact Factor Value 4.046 **e-ISSN: 2456-3463**
National Conference on "Recent Advances in Engineering and Technology" SAMMANTRANA 19
Organized by Government College of Engineering, Nagpur
International Journal of Innovations in Engineering and Science, Vol 4 No.8, 2019
www.ijies.net

A Review on: Development of Structural Concrete using Synthetic, Metallic and Natural Fibers

S. D. Doye [1], Dr. S. A. Tekade[2], Dr. T. P. Bhatkar[3]

[1] *PG Student,*
Yeshwantrao Chavan College of Engineering, Nagpur, India,441108
[2]*Assistant Professor,*
Government College of Engineering, Nagpur, India,441108
[3]*Geotechnical Engineer*
Anandjiwala Technical Consultancy, Nagpur,440022

Abstract- *Plain concrete being brittle suffers form many issues during its design life span. It is well known to improve quality of plain concrete incorporation of fibers plays important role to make it structural concrete. Many researchers incorporate different types of fibers with varying content in their work. This paper reviews various fibers such as synthetic, metallic and natural in different proportion that were added to plain concrete are reviewed and recommendations are suggested as a outcomes of the study. The reviewed approach for the design of Fiber reinforced concrete using different types of fibers is useful to provide appropriate solution to make structural concrete.*

Keywords- FRC, Compressive strength, Flexural, Split Tensile.

I. INTRODUCTION

Concrete is widely used construction material in the world. Because of its ability to get cast in any form and shape, However the weaknesses sometimes limit its use, the fundamental weakness of plain concrete is that cracks start form as soon as concrete is placed and before it has properly hardened[1]. The strength and durability of plain concrete can be changed by making appropriate changes in its ingredients like cementitious material, aggregates and water by adding some special materials like fibers and admixtures. Fiber reinforced concrete (FRC) has been found to improve strength, ductility toughness and durability of structures [2].

Now a day's high strength concrete is preferably used for concrete work, high strength concrete offers various benifits derived from its higher mechanical properties such as high compressive strength, high tensile strength and high stiffness[3]. These properties can be enhanced by adding some sort of fabrics in the concrete. Various types of fibers such as Metallic, synthetic and natural has been used by researchers to make structural Fiber Reinforced Concrete (FRC). In given work attempts have been made incorporating Polypropylene fiber, Steel fiber (hooked end, crimped), glass fiber, Basalt fiber, Jute fiber, Carbon fiber, Hemp, Elephant grass, wheat straw, Cotton fiber, Sisal fiber, raffia fiber, Coconut (Coir) fiber, tie wire fiber and used rubber tires fiber with different aspect ratio [01-37]. Synthetic fiber significantly improves ductility of concrete and helps in crack resistance.

II. DEVELOPMENT OF FRC

G. M. Sadiqul,el.al. [1] evaluated strength, plastic shrinkage and permeability (water and gas) of concrete incorporating polypropylene fiber in different proportion and various physico-mechanical and durability test were done as per EN 12390-3 (2009), EN 12390-6 (2000), ASTM C490, EN 12390-8 (2009) on concrete specimen and results were compared with plain concrete. 50-99% reduction in plastic shrinkage cracks obtained by inclusion of 0.1-0.3% polypropylene fiber by volume, also the water and gas permeability coefficient was increased.

Aminuddin Jameran, et. al. [2] carried out an experiment to investigate mechanical properties of steel and polypropylene

(PP) fiber reinforced concrete under elevated temperature of 27^oC, 200^oC and 400^oC. Fibers were used as steel to PP fiber in various proportion at 1.5% by volume of concrete. Mechanical properties of FRC were investigate as per the recommendations of BS EN 12390-3 (2009), BS EN 12390-5 (2009) and BS EN 14651: 2005+ A1:2007.

A Noumove, et. al.[3] Investigated the effects of fire test on High strength concrete (HSC) and High strength self compacting concrete (HSSCC) by preparing cylindrical and prismatic specimen which were subjected to low heating rate of 0.5^0C/min (up to 400^0C) and high heating rate according to ISO 834 fire curve (up to 600^0C) as recommended by RILEM TC 129 and studied initial and residual mechanical properties of both as per Eurocode 2. Results obtained showed that, the residual mechanical properties in reference to initial mechanical properties were similar to conventional high strength concrete. Addition of Polypropylene fiber improved thermal stability of HSSCC by modifying thermal gradient during heating cooling cycle.

YU Rangang et. al. [4] carried out an experiment to study splitting tensile strength and acoustic emission characteristics of FRC using polypropylene fiber. results obtained showed that, splitting tensile strength increases with increasing fiber content. 13% increase in split tensile strength was achieved at fiber content of 1.8 kg/m^3. water reducer significantly enhanced the effect on splitting tensile strength.

Xixi He and Daqi Peng [5] studied, the influence of polypropylene fiber length, fiber volume fraction and the fiber mixing way on the performance of fresh concrete, also evaluated the performance of fiber reinforce concrete (FRC) slabs with different mix proportion resisting early plastic shrinkage cracks. The results obtained showed that, for crack length, quantity and width, 3 mm short fiber has good inhibitory effects on free drying shrinkage. whereas blending short and long fiber has the best effects on plastic shrinkage and cracking of concrete. As concern with volume fraction, 0.2% polypropylene fiber has best crack resistance effect.

Reju R. and Jiji Jacob G. [6],carried out an experiment to investigates the chemical durability properties of Ultra High performance Fiber Reinforce Concrete (UHPFRC). The cubical specimen were immerged in chemicals (viz.,$H_2SO_{4,}$ Chloride and sulphate) with varying percentage for 60 days. Optimum polypropylene fiber content was 0.9 kg/m^3. Results obtained showed that, the UHPFRC and fly ash based UHPFRC has good resistance to acid attack but showed deterioration when exposed to high concentrated acid, also no deterioration was observed in case of chloride and sulphate.

Cengiz Duran Atis, et. al.[7] studied relation between strength and abrasion resistance of fiber reinforced fly ash concrete. Fly ash was used in various percentage by mass of cement along with steel and polypropylene fiber in different percentage. Flexural strength and compressive strength were relate with abrasion and tested in accordance with TN-ES 12390-3 (2003), TS-12390-5 (2002), TS 699 (2000) and TS

699. Result obtained showed, steel fiber improves abrasion resistance as compared to polypropylene fiber. Flexural strength and abrasion resistance has strong relation as compared to compressive strength and abrasion resistance.

Arabi N. S. Al Qudi, et. al. [8] investigated the effect of specimen shape on residual mechanical properties of polypropylene (PP) fiber self compacting concrete exposed to elevated temperature from 200^0C to 600^0C for 2 and 4 hours. Cylindrical and cubical shaping regimes were prepared and compared results of both with each other. It was found that, thermal shock induced by cylindrical shape air cooling caused more severe damage to concrete in terms of greater losses in compressive strength than those with cubical shapes. PP fiber can enhanced residual strength and fracture energy of concrete subjected to thermal shocks.

Peng zhang, et. al. [9] carried out an experiment to investigate flexural strength and flexural modulus of elasticity of fiber reinforce concrete using polypropylene (PP) fiber at various percent along with different percentage of cement. Result obtained showed, up to 0.1% PP fiber by concrete volume improves flexural strength significantly and decreases flexural modulus of elasticity tested as per recommendations of JTI E30-2005. whereas by increasing curing period and cement content both flexural strength and flexural modulus of elasticity were increased.

Uday Prakashchandra Waghe and Sanjay Padmakar Raut [10], Investigated the behaviour of cement concrete incorporating synthetic fiber. A compressive strength and flexural strength test were done on cube and full scale beam specimen in accordance with IS 516-1959 and results of investigation were compared with control concrete specimen. The best results of the test was noted at minimum fiber content for first crack load and final crack load.

Ali Sadr momtazi and Romina zarshin zanoosh [11] studied, the effect of polypropylene (PP) fiber on cement composite containing rise husk along with rubber particles. Rice husk was used at 10% by cement weight while PP fiber at 0.3% by concrete volume with different percentage of rubber particles. Compressive strength, flexural strength, velocity of ultrasonic wave, water absorption and SEM were analysed. It was observed that PP fiber improves mechanical properties in better way.

Liaqat A. Qureshi, et. al.[12] studied the effect of cocktail fibers on flexural strength of concrete. Undulated steel fiber and monofilament polypropylene fiber were served as cocktail fiber at 60 kg/m^3 steel fiber and 0.7 kg/m^3 & 1.5 kg/m^3 polypropylene fiber in six different groups of specimen. The compressive strength and flexural strength test were done in

accordance with BS 1881 part 108,111,116 :1983. It has been concluded that polypropylene, steel and cocktail fiber enhance cracking behaviour of concrete. Addition of steel fiber reduced compressive strength.

Yan LV, et. al. [13] studied fatigue performance of fiber reinforced concrete (FRC) using glass fiber at three different volume fraction of concrete. The beam specimen of size 100 x 100 x 400 mm was prepared and tested under four point flexural fatigue loading by electro hydraulic universal testing machine (MTS). It was found that, the fatigue performance of GFRC is better than plain concrete.

Youzhi Wang, et. al. [14] performed en experiment to study the impermeability of carbon fiber reinforced concrete. A three different content of carbon fiber with varying length were consider for this experiment and it is found that carbon fiber with 10 mm length has better impermeability.

Job Thomas and Ananth Ramaswamy [15] studied, the mechanical properties of fiber reinforced concrete using hooked end steel fiber. Cubical and cylindrical specimen of proposed size were prepared and tested for compressive strength, spilt tensile strength, modulus of rupture and modulus of elasticity in accordance with IS 516:1959 and 5816:1999. Concrete mix was prepared for three different proportion with varying fiber content. It was found that, Fiber matrix interaction enhanced the mechanical properties of concrete.

Julie Rapoport, et. al. [16] studied, the influence of steel fiber reinforcement on concrete permeability. The splitting tension test (Brazilian test) was conducted on specimen to induced crack up to permissible limit before conducting water permeability test on same specimen as per ASTM C 1202. The steel fibers were used at two different volume fraction of 0.5% and 1.0%. It was observed that steel fibers decreases permeability of specimens.

Yu chen Ou, et. al. [17] carried out an experiment to study compressive behaviour of steel fiber reinforce concrete (FRC) with a high reinforcing index. a cylindrical specimen of FRC containing steel fibers of various reinforcing index were prepared and tested for compressive strength and modulus of elasticity in accordance with ASTM C39 (2003) and ASTM C469 (2002). Result obtained showed, addition of steel fiber had little effect on modulus of elasticity and compressive strength. Long length fiber and fiber having lower aspect ratio resulted a larger increase of the toughness of steel fiber reinforced concrete.

Jean-Francois Trottier and Nemkumar Banthia [18] studied, the toughness characteristics of steel fiber reinforced concrete. three mix proportion with different compressive strength of 42, 52 and 85 MPa were prepared at fiber dosage of 40 kg/m^3 and tested for compressive strength and flexural strength in accordance with ASTM C469 and ASTM C78 for 28 days. It was found that, end deform fibers performed superior than thode deformed through the length.

John Branston, et. al. [19] investigated mechanical behavior of basalt fiber reinforce concrete. Two types of basalt fibers such as bundle despersion and minibars were used as fiber reinforcement and results of both were compared with each other. Compressive strength and flexural strength test were carried out in accordance with ASTM C39 and ASTM C1609. It was found that both type of fiber increased pre-cracking strength but only minibars enhanced post-cracking behavior.

Soon Poh Yap, et. al. [20] studied, the effect of fiber aspect ratio on tortional behavior of steel fiber reinforced normal weight concrete and light weight concrete. steel fibers of aspect ratio 55,60 and 80 were incorporated in concrete at 0.5% by volume. flexural strength, split tensile strength and modulus of elasticity test were done on specimen in accordance with ASTM C78-10, ASTM C496/C496M-11 and ASTM C469-10 respectively. It has been found that, light weight concrete made from Oil palm shell concrete has better performance in torsion than normal weight concrete. Steel fiber effectively improves tensile strength, mechanical properties, ductility, toughness and crack resistance of light weight concrete aspect ratio of 80 among three has better performance in tensional behaviour of concrete.

Sherif Yehia, et. al. [21] studied, mechanical and durability properties of fiber reinforced self compacting concrete incorporating steel, synthetic and hybrid fibers and tested for compressive strength, split tensile strength, flexural strength, modulus of elasticity and rapid chloride permeability test in accordance with BS En 12390-3, ASTM C39, ASTM C496, ASTM C78, ASTM C469 and ASTM C1202 respectively. Results showed, All three fibers improved mechanical and durability properties significantly. The microstructure of synthetic fiber reinforced self compact concrete and steel fiber reinforced self compact concrete was different and affects on respective crack resistance mechanism.

Shi Yin, et. at. [22] carried out an experiment to compare alkali resistance of recycled and virgin polypropylene fiber reinforced concrete along with some mechanical properties. Two mix proportions of 25 Mpa and 40 Mpa were prepared and results were compared with each other. Result showed, recycled polypropylene fiber produces better reinforcement than that of virgin polypropylene fiber.

Xi angming Xhou, et. al. [23] studied,the fracture and impact properties of short discrete jute fiber reinforced cementatious composite. The fracture properties, impact resistance, compressive strength, flexural strength and split tensile strength were tested in accordance with several EN standards. Result showed, Jute fiber has good effect on fracture properties and impact resistance.

Adewumi John Babafemi and William Peter Boshoff [24] investigated the time dependent behaviour of fiber reinforced concrete (FRC) incorporating polypropylene fiber. The prismatic specimen were prepared and tested for Uniaxial tension, shrinkage and uniaxial creep test. Results revealed that, cracked macro synthetic FRC shows significant creep and fiber creep.

N. Buratti and C. Mazzotti [25] studied, the effect of temperature on short term and long term behaviour of Macro synthetic fiber reinforced concrete (MSFRC). Four different types of macro synthetic fibers were used for two different size of prismatic specimen. Three point bending test were carried out for short term properties at 20^0C and 40^0C in accordance with EN 14651 and four point bending test for long term properties at 20^0C-50 ^{0}C along with compression and elastic modulus also tested on cubical and cylindrical specimen. Results showed, Temperature affects short term and long term behaviour of MSFRC.

I. Merta and E. K. Tschegg [26] performed an experiment to study fracture energy of natural fiber reinforced concrete. A Hemp, Elephant grass and Wheat straw were used as natural fibers of 40 mm length at dosage of 4.5 kg/m^3. A Wedge Splitting Test (WST) were performed on specimen of 150 x 150 x 120 mm with rectangular notch at top of 30 mm length and 3 mm wide to study fracture properties. Results showed, hemp fiber performed well compared to plain concrete and concrete with elephant grass and wheat straw. Hemp fiber increased fracture energy up to 70% and has better bounding with concrete.

Vikrant S. vairagade and Kavita S. kene [27] carried out an experiment to study the strength of normal concrete using metallic and synthetic fibers. Steel fiber of hooked end with different aspect ratio and crimped round were used as metalic fiber at fiber content of 0% and 0.5% by concrete volume, where as fibrillated polypropylene fiber with 15mm, 20mm and 24mm cut out length was used as a synthetic fiber at fiber content of 0.4% by cement weight. The cubical and cylindrical specimen were prepared and tested for compressive strength and split tensile strength in accordance with IS 516-1959 and IS 5816-1999. It has been concluded that, there is a positive effect of steel and polypropylene fiber on improvement of compressive and split tensile strength of concrete specimen at 7 and 28 days.

K. Korniejenko, et. al. [28] studied the influence of four different natural fibers such as cotton, sisal, raffia and coconut (coir) fiber on fly ash based geopolymer concrete. The cubical and prismatic specimen were prepared incorporating each fiber at 1% by weight of composite (NaOH) and tested for compression and flexural strength in accordance with EN 12390-3 and EN 12390-5 respectively. Results obtaine showed, cotton, sisal or coir fiber had relatively good mechanical properties as compared to raffia fiber.

Mahyuddin Ramli, et. al. [29] investigated strength and durability of coconut fiber reinforced concrete in aggressive environment. The fiber dosage were not used exceeding 1.2% of binder volume. The compressive strength, flexural strength, chloride penetration and intrinsic permeability were checked and discussed.

Drago Saje, et. al. [30] studied, shrinkage behaviour of high performance concrete by using dry and previously moist polypropylene (PP) fiber of varied percentage up to 0.75% by concrete volume. Shrinkage test was done using electronic displacement transducer in accordance with Japanese standards (Jazawa 1999) along with compressive strength and flow test of concrete with the help of EN 12390-3 (CEN 2009b) and EN 12350-5 (CEN 2009a) respectively. Results obtained showed, at fiber content 0.5%, the shrinkage of FRC reduced significantly while further increasing fiber content shrinkage reduction was insignificant. Moist PP fiber slightly increase workability with lesser degree of early autogenous shrinkage as compared to dry PP mix.

YU Rangang, et.al. [31], researched influence of fiber content and specimen size on fracture energy, unstable fracture toughness and critical crack tip opening displacement of polypropylene fiber reinforced concrete.

Results showed, there is no drastic change in fracture properties for changing dimension of specimens. However, 0.9 kg/m^3 polypropylene fiber content was found to be optimum for best results.

Li Yi [32], carried out an experimental work to check impermeability of reinforced concrete used to the nuclear waste container by using two different type steel fibers with change in length and polypropylene fiber. The compression and impermeability test were done according to GBJ81-85 before and after heating at 150^{o}C. It was observed that, compressive strength is higher at minimum doses of all fibers.

LIV Juan hang, et.al. [33], Investigated into application of light weight aggregate concrete in old bridge deck pavement using polypropylene fibers. it is observed that, Polypropylene fiber can improve early age crack resistance.

Gao Jianhua [34], Studied application of polypropylene fiber reinforcement in concrete bridge deck. The seepage height, compressive and spilt tensile behaviour were checked for ordinary and polypropylene fiber reinforced concrete. It was found that, polypropylene fiber is a good crack arrestor in concrete bridge deck.

V. K. R. Kodur, et. al. [35], studied effect of fiber reinforcement on fire resistance of high strength concrete column. steel and polypropylene fibers were used in different mixes and column specimen was tested at 28 days and 90 days. Results of study showed, addition of polypropylene fiber improved fire resistance.

Dipti Ranjan Sahoo, et. al. [36], Studied an influence of steel and polypropylene fiber on flexural, compressive and split tensile strength of concrete according to IS 516-1959. Maximum values of flexural strength was noticed when combine fiber used.

Teuku budi Aulia and Rinaldi [37], Carried out and experimental work to study bending capacity of environmentally friendly synthetic fibers ie., polypropylene fiber, tie wire fiber and used rubber tires fiber. It was observed that compressive strength of cylindrical specimen is more in case of polypropylene fiber where as bending strength of beam specimen is more in case of tie wire fiber tested at 28 days.

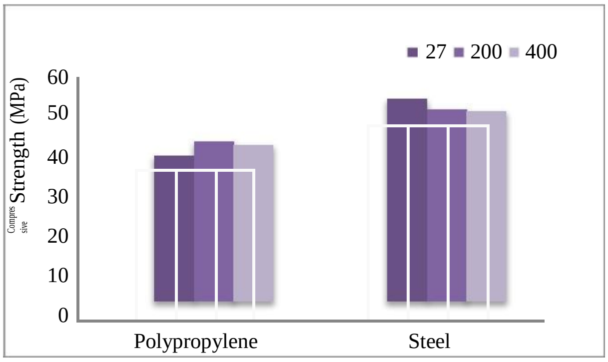

Fig. 1. Compressive strength after heating at 28 days

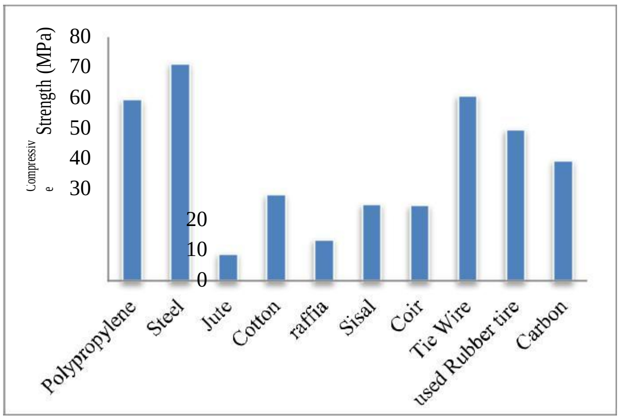

Fig. 2. Compressive strength at 28 days

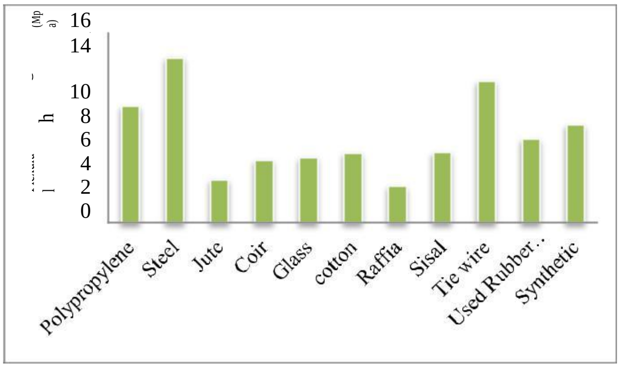

Fig. 3. Flexural strength at 28 days

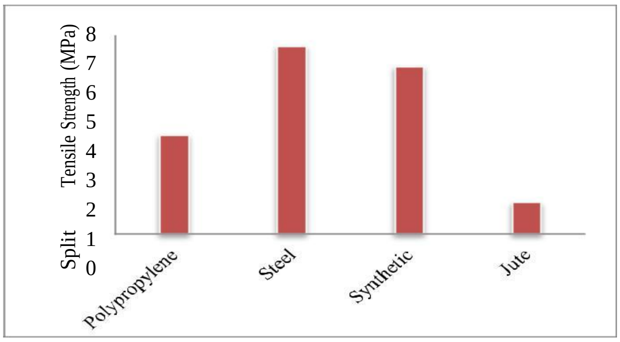

Fig. 4. Splitting Tensile strength at 28 days

Table 1. Design of fiber reinforced concrete

Ref.	Fiber Type	Fiber Content	Admixture	Specimens (Sizes in mm)				Tests conducted
				Cube	Beam	Cylinder	Slab	
1	Polypropylene	0.1% to 0.3%	super plasticizer	150 x 150 x 150	-	-	500 x 250 x 75	Compressive strength, Tensile Strength, Shrinkage Test, Permeability (water and gas)
2	Polypropylene	1.5%	-	150 x 150 x 150	150 x 150 x 550	150D x 300H	-	compression test, split tensile, flexural test at exposed temprature of 200^oC & 400^oC for 60 min.
	Steel	1.5%						
3	Polypropylene	2 kg/m^3	Superplasticizer, retarding admixture	-	100 x 100 x 400	160D x 320H	-	compression and flexural strength test at temperature 400^oC & 600^oC
4	Polypropylene	0.45 to 1.8 kg/m^3	-	100 x 100 x 100	-	-	-	Split Tensile Test, Acoustic emmision test
5	Polypropylene	0.1% to 0.2%	super plasticizer	-	-	-	600 x 600 x 63	Drying Shrinkage Test
6	Polypropylene	0.9 kg/m^3	Super plasticizer (PCE)	150 x 150 x 150	-	-	-	Acid Attack (0.5,1.0,2.0% H_2SO_4), Sulphate Attack, chloride Attack test.
7	Polypropylene	0.05% to 0.2%	Hyper-plasticizer (PC)	71 x 71 x 71 and 150 x 150 x 150	100 x 100 x 500	-	-	compressive strength test, flexural test, abrasion resistance test
	Steel	0.25% to 1.5%						
8	Polypropylene	0.05% to 0.15%	super plasticizer	100 x 100 x 100	-	75D x 150H	-	Compressive Strength test at Temperature of 200^oC, 400^oC and 600^oC.
9	Polypropylene	0.04% to 0.1%	-	-	100 x 100 x 400	-	-	Flexural test (4 point bending), Flexural elastic modulus
10	Synthetic Fiber	0.25% to 1.5%	-	150 x 150 x 150	150 x 150 x 700	-	-	Compressive Strength Test, Flexural Test
11	Polypropylene:	0.3%	super plasticizer	50 x 50 x 50	50 x 50 x 200	-	-	Compressive strength, flexural strength, velocity of ultrasonic wave, water absorption and SEM.
12	Polypropylene:	0.7 and 1.5 kg/m^3	-	150 x 150 x 150	150 x 225 x 1975	-	-	compressive strength test, flexural strength test.
	Steel	60 kg/m^3						
13	Glass	0.6 to 1.0%	-	100 x 100 x 100	100 x 100 x 400	-	-	Flexural fatigue strength test.
14	Carbon	0.2% to 0.5%	-	-	-	-	-	Permeability Test
15	Steel	0.5% to 1.5%	super plasticizer	150 x 150 x 150	100 x 100 x 500	150D x 300H	-	Compressive strength, split tensile strength, Modulus of rupture, modulus of

								elasticity.
16	Steel (Hooked end)	0.5% and 1.0%	super plasticizer	-	-	100D x 200H	-	Split tensile test, Water permeability.
17	Steel	0.4% to 1.7%	super plasticizer	-	-	150D x 300H	-	Compression test, modulus of elasticity.
18	Steel: (hooked end, crimped, twin cone)	40 kg/m^3	water reducing agent, Air entraining agent	-	100 x 100 x 350	100D x 200H	-	Compressive strength, flexural strength.
19	Basalt Fiber	0.15% to 0.46%	Super plasticizer	-	152 x 152 x 610	100D x 200H	-	Compressive strength, flexural strength.
20	Steel	0.5%	-	-	100 x 100 x 500	100D x 200H and 150D x 300H		Flexural strength, Split tensile strength, modulus of elasticity.
21	Steel	0.5%	-	150 x 150 x 150	100 x 100 x 500	150D x 300H,, 100D x 200H and 100D x 50H	-	Compressive strength, split tensile strength, flexural strength, modulus of elasticity, chloride permeability.
	Synthetic	0.5%						
	Hybrid	0.25%						
22	Polypropylene: (virgin and recycled)	4 kg and 6 kg	-	-	150 x 150 x 600	100D x 200H	-	Compressive strength, flexural strength, alkali resistance.
23	Jute	0.5%	-	-	100 x 100 x 200	100D x 200H	-	Compression test, split tensile test, fracture test, impact test.
24	Polypropylene	1%	Plasticizer	-	100 x 100 x 500	-	-	Uniaxial tension, Shrinkage, Uniaxial creep.
25	Synthetic	3 to 7 kg	-	150 x 150 x 150	150 x 150 x 550 and 300 x 120 x 2000	150D x 300H	-	Compressive strength, elastic modulus, Three point bending test (at 20ºC and 40ºC) Four point bending test (at 0ºC to 50ºC)
26	Hemp	4.5 kg/m^3	Super Plasticizer	150 x 150 x 150	-	-	-	Fracture Mechanical Test (Wedge Splitting Test)
	Elephant Grass	4.5 kg/m^3						
	Wheat Straw	4.5 kg/m^3						
27	Polypropylene	0.4% by weight	-	150 x 150 x 150	-	100D x 200H	-	Compressive strength, split tensile strength.
	Steel	0.5% by vol.						
	Cotton	1%	Sodium		50 x 50 x			Compressive strength,
	Sisal	1%						

28	 Coir Raffia	 1% 1%	hydroxide solution	50 x 50 x 50	200	-	-	flexural strength
29	Coir	0.6 to 2.4 %	Super Plasticizer	-	100 x 100 x 500	-	-	Compressive strength, flexural strength, Chloride penetration, intrinsic permeabiliity.
30	Polypropylene: (Dry and Moist)	0.25% to 0.75%	Super plasticizer	150 x 150 x 150	-	-	-	Autogenous Shrinkage and Total Shrinkage.
31	Polypropylene	0.9 kg/m^3	-	-	100 x 100 x 515	-	-	Fracture Energy, Fracture toughness
32	Polypropylene Steel (Sheared Thread) Steel (Super Short and Fine)	0.3 and 0.9 kg/m^3 40 and 80 kg/m^3 8 and 24 kg/m^3	Water Reducer	-	-	-	-	Compressive Strength Test, Impermeability Test
33	Polypropylene Steel	0.9 Kg/m^3 50 kg/m^3	Water Reducing Agent, Viscosity Increasing Agent	-	-	-	-	Compressive Strength, Flexural Strength, Split Tensile Strength, Elastic Modulus
34	Polypropylene	0.5 to 1.0 kg/m^3	Retarder	-	-	-	-	Compressive Strength, Split Tensile Strength, Seepage Height
35	Polypropylene Steel	0.9 kg/m^3 42 kg/m^3	Super plasticizer	-	-	-	-	Compressive Strength
36	Polypropylene Steel	0.5% and 1.0% 0.5% and 1.0%	Super Plasticizer	150 x 150 x 150	100 x 100 x 500 and 150 x 200 x 2000	100D x 200H	-	Compressive Strength, Split Tensile Strength, Flexural Strength Test
37	Polypropylene Tie wire Used rubber tires fiber	0.2% 2% 0.75%	Super Plasticizer	-	150 x 150 x 600	150D x 300H	-	Compressive Strength, Flexural Test

III. DISCUSSION

Various fibers including Synthetic, Metallic and Natural from literatures are studied and review of them is presented in the form of compression \strength and bending strength. Table 1 Shows the various fibers used along with fiber content in reviewed literatures, also admixture, specimens prepared and test conducted on that specimens for each fiber case is presented. Fig.1. shows compressive strength of polypropylene fiber and steel fiber at 27^{o}C, 200^{o}C and 400^{o}C. It was found that, compressive strength is more in steel FRC than Polypropylene FRC and there was a little effect on compressive strength after increasing temperature. However, Steel fiber has greater compressive strength at 28 days of testing. A polypropylene fibber and Tie wire fiber also shows maximum values of compressive strength than other fibers shown in Fig.2.

As like compressive strength, Flexural strength was also found more in Steel fiber, Tie wire fiber and Polypropylene fiber than other fibers shown in Fig.3. A splitting tensile characteristics of FRC was better in case of Steel and Synthetic fiber as shown in Fig.4.

IV. CONCLUSION

Steel fiber can be adoptable to modify compressive, split tensile and flexural properties of fiber reinforced concrete. Also Tie wire fiber and polypropylene fiber found to be good reinforcing material to enhance properties of concrete.

However, some admixtures may be used along with these fibers to encounter issues occurred at fresh state and hardened state of concrete.

REFERENCES

[1] *G.M. Sadiqul and Sristi Das Gupta(2016) Evaluating plastic shrinkage and permeability of polypropylene fiber reinforced concrete. International Journal of Sustainable Built Environment*

[2] *Aminuddin Jameran, Izni S. Ibrahim, Siti Hamizah S. Yazan and Siti Nor A. A. Rahim.(2015) Mechanical Properties of steel-polypropylene fiber reinforced concrete under elevated temperature.EACEF-5. pp 1877-7058.*

[3] *Noumowe, H. Carre, A. Daoud and H. Toutanji(2006) High Strength Self Compacting Concrete Exposed to Fire Test. Journal of Materials in Civil Engineering pp 754-758.*

[4] *YU Rangang, Huang Bao, Zhang Jian and Wang Jialing(2011) Experimental Study on Splitting Tensile Strength and Acoustic Emission Characteristics of Polypropylene Fiber Concrete. IEEE ; 978-1-4577-0290-7*

[5] *Xijxi He and Daqi Peng (2011) Experimental Study on Crack Resistance Property of Fresh Polypropylene Fiber Concrete. IEEE ;978-1-61284-774-0/11.*

[06] *Reju R. and Jiji Jacob G (2012) Investigations on the Chemical Durability Properties of Ultra High Performance Fiber Reinforced Concrete. IEEE ; 978-1-4673-2636-0.*

[7] *Cengiz Duran Atis, Okan Karahan, Kamuran Ari, Oziem Celik and Cahit Bilim (2009) Relation between Strength Properties (Flexural and Compressive) and Abrasion Resistance of Fiber (Steel and Polypropylene) Reinforced Fly Ash Concrete. Journal of Materials in Civil Engineering ;pp 402-408.*

[8] *Arabi N.S. Al Qadi and Sleiman M. Al-Zaidyeen (2012) Effect of fiber content and specimen shape on residual strength of polypropylene fiber self compacting concrete exposed to elevated temperature. Journal of King Saud University-Engineering Sciences;pp 1018-3639*

[9] *Peng Zhang, Qingfu Li and Hua Wei (2010) Investigation of Flexural Properties of Cement Stabilized Mecadam Reinforced with Polypropylene Fiber. Journal of Materials in Civil Engineering;pp 1282-1287.*

[10] *Uday Prakashchandra Waghe and Sanjay Padmakar Raut (2011) Investigations into synthetic fiber reinforced concrete beams. Advanced materials research.;vols. 255-260.pp 284-288.*

[11] *Ali sadr momtaji and Romina zarshin zanoosh (2011) The effect of polypropylene fibers and rubber particles on mechanical properties of cement composite containing rise husk ash. ICM 10; pp 3608-3615.*

[12] *Liaqat A. Qureshi, M. Ilyas Sheikh and Tahir Sultan (2013) Effect of Mixing Fiber Cocktail on Flexural Strength of Concrete. The 2nd International Conference of Rehabilitation and Maintenance in Civil Engineering;pp 1877-7058.*

[13] *Yan Lv, He-ming Cheng and Zhi-gaung Ma (2011) Fatigue performance of glass fiber reinforced concrete in flexure. International conference on Advances in Computational Modeling and Simulation;pp 1877-7058.*

[14] *Youzhi Wang, Xiaowei Wen and Yuanyuan Sun (2008) Experimental Study on CFRC Impermeability. International Symposium on Information Science and Engieering;978-0-7695-3494-7.*

[15] *Job Tomas and Ananth Ramaswamy (2007) Mechanical Properties of Steel fiber reinforced concrete. Journal of Materials in Civil Engineering; pp 385-392.*

[16] *Julie Rapoport, Corina Maria Aldea, Surendra P. Shah, Bruce Ankenman and Alan Kan (2002) Permeability of Cracked steel fiber reinforced concrete. Journal of Materials in Civil Engineering;pp 355-358.*

[17] *Yu-Chen Ou, Mu-Sen Tsai, Kuang-Yen Liu and Kuo-Chun Chang (2012) Compressive Behavior of Steel Fiber Reinforced Concrete with a High Reinforcing Index. Journal of Materials in Civil Engineering; pp 207-215.*

[18] *Jean Francois Trottier and Nemkumar Banthia (1994) Toughness Characterization of steel fiber reinforced concrete. Journal of Materials in Civil Engineering;pp 264-289.*

[19] *John Branston, Sreekanta Das, Sara Y. Kenno and Craig Taylor (2016) Mechanical behaviour of basalt fibre reinforced concrete. Construction and Building Materials;pp 878-886.*

[20] *Soon Poh Yap, Kuan Ren Khaw, U. Johnson Alengaram and Mohd Zamin Jumaat (2015) Effect of fiber aspect ratio on the torsional behavior of steel fiber reinforced normal weight concrete and light weight concrete. Engineering Structures;pp 24-33.*

[21] *Sherif Yehia, AlaEddin Douba, Omar Abdullahi and Sharef Farrag (2016) Mechanical and Durability evaluation of fiber reinforced*

self compacting concrete. Construction and Building Materials ; pp120-133.

[22] *Shi Yin, Rabin Tuladhar, Jacob Riella, David Chung, Tony Collister, Mark Combe and Nagaratnam Sivakugan (2016) Comparative evaluation of virgin and recycled polypropylene fibre reinforced concrete. Construction and Building Materials;pp 134-141.*

[23] *Xiangming Zhou, Seyed Hamidreza Ghaffar, Wei Dong, Olayinka Oladiran and Mizi Fan (2013) Fracture and impact properties of short discrete jute fibre-reinforced cementitious composites. Materials and Design;pp 35-47.*

[24] *Adewumi John Babafemi and William Peter Boshoff (2015) Tensile Creep of Macro-Synthetic fiber reinforced concrete under uni-axial tensile loading. Cement and Concrete Composites;pp 62-69.*

[25] *N. Buratti and C. Mazzotti (2015) Experimental tests on the effect of temperature on the long-term behavior of macro-synthetic fiber reinforced concrete. Construction and Building Materials;pp 133-142.*

[26] *I. Merta and E.K. Tschegg (2013) Fracture energy of natural fibre reinforced concrete. Construction and Building Materials;pp 991-997.*

[27] *Vikrant S. Vairagade and Kavita S, Kene (2013) Strength of Normal Concrete Using Metallic and Synthetic Fibers. Chemical, Civil and Mechanical Engineering Tracks of 3rd Nirma University International Conference;pp 1877-7058.*

[28] *K. Korniejenko, E. Fraczek, E. Pytlak and M. Adamski(2016) Mechanical Properties of geopolymer composites reinforced with natural fibers. ICEBMP;pp 388-393.*

[29] *Mahyuddin Ramli, Wai Hoe Kwan and Noor Faisal Abas (2013) Strength and durability of coconut fiber reinforced in aggressive environments. Construction and Building Materials;pp 554-566.*

[30] *Drago Saje, Branko Bandeji, Jakob Sustersic, Joze Lopatic and Franc Saje (2011) Shrinkage of Polypropylene Fiber Reinforced High Performance Concrete. Journal of Materials in Civil Engineering;pp 941-952.*

[31] *YU Rangang, Zhou Jinshun, Li Zhingming and Ran Yanhua (2011) Influence of fiber content and specimen size on fracture property of polypropylene fiber concrete. IEEE;978-1-4577-0290-7*

[32] *Li Yi. (2009) The experimental research on the impermeability of reinforced concrete used to the nucleas waste container. IEEE;978-1-4244-2902-8*

[33] *LIU Juan hong, SONG Shao min, ZHONG Jian feng and CHEN Xiao fang (2010) Application of lightweight aggregate concrete in old bridge deck pavement engineering. IEEE;978-1-4244-7161-4*

[34] *Gao Jianhua (2012) On the application of polypropylene fiber reinforced concrete in the bridge deck. IEEE;978-0-7695-4639-1*

[35] *V.K.R. Kodur, Fu Ping Cheng, Tien Chih Wang and M. A. Sultan (2003) Effect of strength and fiber reinforcement on fire resistance of high strength concrete columns. Journal of structural engineerin;129(2) pp.253-259*

[36] *Dipti Ranjan Sahoo, Apekshit Solanki and Abhimanjyu Kumar (2015) Influence of steel and polypropylene fibers on flejxural behavior of RC beams. Journal of materials in civil engineering;27(8)04014232*

[37] *Teuku Budi Aulia and Rinaldi (2015) Bending capacity analysis of high strength reinforced concrete beams using environmentally friendly synthetic fiber composites Procedia Engineerin.;125 pp 1121-1128*

[38] *EN 12390-3 (2009): Testing Hardened concrete. Compressive strength of test specimen:2009*

[39] *EN 12390-6 (2000): Testing Hardened concrete-part 6. Tensile splitting strength of test specimens;2000.*

[40] *American Society for testing and Materials: ASTM C 490-2011. Standard practice for use of apparatus for the determination of length change of hardened cement paste, mortar and concret;2011*

[41] *EN12390-8 (2009): Testing Hardened concrete-part 8. Depth of penetration of water under pressure;2009.*

[42] *RILEM TC 129: Test method for mechanical properties of concrete at high temperatures.*

[43] *EUROCODE 2: Design of concrete structures.*

[44] *TS-ES 12390-3 (2003): Testing hardened concrete. Compressive strength of test specimens;2003.*

[45] *TS-12390-5 (2002): Testing hardened concrete. flexural strength of test specimens;2002.*

[46] *TS 699 (2000): Method of testing for natural building stones;2000.*

[47] *TS 699: Method of testing for natural building stones.*

[48] *BS EN 14651 : 2005 + A1:2007: Test Method for metallic fiber concrete. Measuring the flexural tensile strength (limit of proportionality(LOP), residual);2005.*

[49] *BS 1881 part 108 (1983): Testing concrete. Method for making test cubes from fresh concrete;1983.*

[50] *BS 1881 part 111 (1983): Testing concrete. Method of normal curing of test specimens (20^{o}C method);1983.*

[51] *BS 1881 part 116 (1983): Testing concrete. Method for determination of compressive strength of concrete cubes;1983.*

[52] *Bureau of Indian Standards(1959): IS 516-1959. Method of test for strength of concrete.*

[53] *Bureau of Indian Standards(1999): IS 5816-1999.Splitting tensile strength of concrete-method of test.*

[54] *American Society for testing and Materials: ASTM C 1202. Standard test method for electrical indication of Concrete's ability to resist chloride ion penetration.*

[55] *American Society for testing and Materials: ASTM C 39-2003. Standard test method for compressive strength of cylindrical concrete specimens;2003*

[56] *American Society for testing and Materials: ASTM C 469-2002. Standard test method for Static modulus of elasticity and Poisson's ratio of concrete in compression;2002*

[57] *American Society for testing and Materials: ASTM 78. Standard test method for Flexural strength of concrete (Using simple beam with third point loading).*

[58] *American Society for testing and Materials: ASTM C 1609. Standard test method for Flexural performance of fiber reinforced concrete (Using beam with third point loading).*

[59] *American Society for testing and Materials: ASTM C 496 / C 496 M-11. Standard test method for splitting tensile strength of cylindrical concrete specimens;2011.*