COMPRESSIVE STRENGTH AND SORPTIVITY PROPERTIES OF PET FIBER REINFORCED CONCRETE

R. N. Nibudey[1], P. B. Nagarnaik[2], D. K. Parbat[3], A. M. Pande[4]
[1]Research Scholar, Yashvantrao Chavhan College of Engineering, Nagpur- 441110, Maharashtra, India.
[2]Professor, Department of Civil Engineering, G.H. Raisoni College of Engineering, Nagpur-440016, Maharashtra, India
[3]Department of Civil Engineering, Government Polytechnic, Sakoli, Maharashtra, India.
[4]Professor, Department of Civil Engineering, Yashvantrao Chavhan College of Engineering, Nagpur-441110, Maharashtra, India

ABSTRACT
This paper presents experimental results of compressive strength and sorptivity for normal concrete and PET fiber reinforced concrete (PFRC). The PET fibers used in this study were obtained manually from waste mineral water bottles. Two grades, M20 and M30, of concrete and two fiber geometry of aspect ratios 35 and 50 with fiber volume fractions 0.0 to 3.0% were used in the experiments. Each specimen was tested after 28 days of curing. It was found that the compressive strength of PFRC increased and the sorptivity of PFRC was decreased with respect to normal concrete. The optimum fiber volume fraction of PET fibers was found to be 1%. From the test results, mathematical models for predicting sorptivity of PFRC in terms of compressive strength and fiber volume fraction were established and which works within 90% confidence limit. The addition of PET fibers in concrete tends to restrict water propagation in the concrete and causes reduction in sorptivity. The decrease in sorptivity of PFRC is favorable to the durability of the reinforced cement concrete structures. The fibers used in the study were made up from waste plastics which help to reduce the cost FRC and resolve solid waste disposal problems also.

KEYWORDS: *Concrete, Waste plastics, PET fibers, Compressive strength, Sorptivity.*

I. INTRODUCTION

Concrete is a miraculous man made material for civil engineering construction which is preferred to use all over the world, due to its strength, structural stability, high mould ability and low cost. Concrete is the backbone for infrastructural development of whole world.

The concrete has many advantageous properties such as good compressive strength, durability, impermeability, specific gravity and fire resistance. However the concrete has some bitter properties like - weak in tension, brittleness, less resistance to cracking, lower impact resistance, heavy weight, etc. To overcome some of these bitter properties of concrete, the discrete fibers can be added as one of the ingredients of concrete. The fibers inclusion in cement base matrix acts as unwanted micro crack arrester. The prevention of prorogation of cracks under load can result in improvement in static and dynamic properties of cement based matrix. The serviceability of fiber reinforced cement concrete is also enhanced due to restricting entry of water and other contaminants through micro cracks which causes corrosion to steel reinforcement.

Waste is the one of the main challenges to dispose and manage. It has become one of the major environmental, economical and social issues. Recycling is the most promising waste management process for disposal of waste materials. The waste utilization in Civil Engineering construction has become an attractive alternative for disposal and protecting environment.

Industrial activities are associated with significant amount of non-biodegradable solid waste. The waste plastic is being among the most prominent. The waste polyethylene terephthalate (PET) bottles are recycled and used in industries for different purposes. The recycled waste plastics in different forms are being use in pavements, bridges, floors, dams and many other civil engineering works.

The advantage of using waste plastic in concrete not only solves the problem of their safe disposal but also improves the basic properties of concrete like compressive strength, tensile resistance, impact resistance, permeability, flexural strength, thermal insulation, etc. The main benefit of using plastics in concrete is its durability, resistance to chemicals and light in weight. The main disadvantage of using plastic in concrete is that it has smooth surface, their bond characteristics become a hindrance to use them as concrete ingredient. It has low melting point so that it cannot be used in furnaces.

The use post-consumer plastic waste as concrete ingredient will beneficial to environment safety but the process of making recycled plastic suitable for concrete is energy intensive. Therefore, energy efficient method is required to be developed which will helpful to reduce the cost production and the experimental analysis plastic reinforced concrete needs an urgent attention for further investigation.

From previous research works it is clear that the post consumed polyethylene teraphthelne (PET) bottles in fiber form can be used to improve the mechanical properties of concrete. The PET fibers inclusion in concrete is an innovative material that can be promote in construction field. The plastic fibers developed from waste plastics thorough recycling process are costly that's why in this study the fibers were obtained by cutting post consumed PET mineral water bottles into desired shape and size. M20 and M30 grades of concrete, and 35 and 50 aspect ratios of PET fibers were selected for experimental study. The compressive strength and sorptivity of PET fiber reinforced concrete was determined at various percentages of fibers after 28 days of curing of specimens. On the basis of test results, mathematical models for predicting sorptivity of PFRC were established and presented with their confidence limit.

II. LITERATURE REVIEW

A comprehensive review of the work carried out by various researchers in the field of using recycled plastics in concrete is discussed below.

Batayneh M. *et al.* [1] investigated the effect of ground plastic on the slump of concrete. Concrete mixes of up to 20% of plastic particles are proportioned to partially replace the fine aggregates. It was observed that there is a decrease in the slump with the increase in the plastic particle content. For a 20% replacement, the slump has decreased to 25% of the original slump value with 0% plastic particle content. Soroushian P. *et al*. [2] reported reduction in slump with the use of recycled plastic in concrete. Ismail Z.Z. and Hashmi E. A. [3] have also found that the slump is prone to decreasing sharply with increasing the waste plastic ratio. Al-Manaseer A. A. and Dalal T. R. [4] investigated the effect of plastic aggregates on the bulk density of concrete. They concluded that the bulk density of concrete decreased with the increase in plastic aggregates content.

Choi Y. W. *et al.* [5] studied the effects of polyethylene terephthalate (PET) bottles lightweight aggregate (WPLA) on the compressive strength of concrete. It was found that compressive strength of concrete mixtures decreased with the increase in PET aggregates. Marzouk O. Y. *et al*. [6] experimented the innovative use of consumed plastic bottle waste in granule form as sand substitution aggregate within composite materials for building application. Bottles made of polyethylene terephthalate (PET) were used as partial and complete substitutes for sand in concrete composites. Various volume fractions of sand varying from 2% to 100% were substituted by the same volume of granulated plastic, and various sizes of PET aggregates. They concluded that substituting sand at a level below 50% by volume with granulated PET, whose upper granular limit equals 5 mm, affected the compressive strength of composites and plastic bottles shredded into small PET particles may be used successfully as sand-substitution aggregates in concrete composites.

Ochi T. *et al.* [7] investigated development of recycled PET fiber and its application as concrete-reinforcing fiber and described a method that can be used to produce concrete-reinforcing PET fiber from used PET bottles. The issue of concern in the development of PET fiber was its alkali resistance and they encountered no problems when using these fibers in normal concrete. Kim Sung Bae *et al.* [8] proved structural performance evaluation of recycled PET FRC. A procedure to recycle waste PET bottles is presented, in which short fibers made from recycled PET are used within concrete. To verify

the performance capacity of recycled PET fiber reinforced concrete, it was compared with that of polypropylene (PP) fiber reinforced concrete for fiber volume fractions of 0.5%, 0.75%, and 1.0%. The compressive strength, elastic modulus, and restrained drying shrinkage strain were computed experimentally. The test results show that compressive strength and elastic modulus both decreased as fiber volume fraction increased and cracking due to drying shrinkage was delayed in the PET fiber reinforced concrete specimens, compared to such cracking in no reinforced specimens without fiber reinforcement, which indicates crack controlling and bridging characteristics of the recycled PET fibers.
Foti Dora [9] experimented on fiber-reinforced concrete; the improvements in ductility of the concrete were reported. Pelissera Fernando *et al*. [10] have reported an increase in the compressive strength and the tensile strength obtained from the flexure was observed for recycled PET bottle fiber reinforced concrete. Shamskia N. [11] has added different contents of PET fibers (0, 0.5, 1.0, 1.5 %) to a concrete mixture and the workability of fresh concrete samples were observed to be decreasing on increasing the content of PET fibers. The ductility and energy absorption of the concrete samples was found to be increased by adding the PET fibers to the concrete mixture. Afroz Mahzabin *et al*. [12] have investigated the improvement in shear capacity on addition of plain PET-fibers to concrete. Shear capacity of concrete beam was increased by 30%, 70%, and 50% due to addition of PET-fibers of 0.40%, 0.46%, and 0.52% respectively, compared to the plain concrete specimen. Nibudey R. N. *et al.* [13, 14, 15, and 16] optimized the benefits of using post consumed waste PET bottles in the fiber form in concrete. The concrete of M20 and M30 grades of concrete with two aspect ratios 35 and 50 of waste plastic fibers were experimented to determine green and harden properties concrete. It was observed that slump, compaction factor and dry density of concrete reduces as compared to normal concrete when fiber content increases and reduction in these values found higher for larger value of aspect ratio. It was observed that improvement in properties of concrete was higher for aspect ratio 50 than aspect ratio 35.

The past research encourage that the recycled plastics can be used in concrete for improving its property. The use of plastics in fiber form has given better results than granule forms. In this paper models for prediction of sorptivity in terms of cube compressive strength and fiber volume fraction is developed.

III. EXPERIMENTAL PROGRAMME

3.1. Materials Used

3.1.1.Cement

Portland Pozzolana Cement (Fly Ash based) was used in this experimentation conforming to IS: 1489-1991 (Part I) [17]. The physical properties of cement used in the study are as given in Table 1.

Table 1 The physical properties of Portland Pozzolana Cement

Fineness (%)	Normal consistency (%)	Initial setting time (Minute)	Final setting time (Minute)	Soundness (Le-Chat.) (mm)	28 days compressive strength (MPa)
2.7	32	210	330	1.5	50.7

3.1.2. Aggregates

Locally available natural sand from river was used as fine aggregate and the crushed stone aggregates were collected from the local query, in this study. The maximum sizes of aggregates were 20 mm and 10 mm. The fine and coarse aggregates were tested as per IS: 383-1970[18] and 2386-1963 (Part I,II and III) specifications[19]. The physical properties of aggregates used in the study are as shown in Table 2 and 3

Table 2 The physical properties of fine aggregates

Specific gravity	Bulk density (kg/cu.m)	Fineness modulus	Water absorption (%)	Silt content (%)	Grading zone (IS 383-1970
2.53	1718.52	2.62	1.2 %	0.61	II

Table 3 The physical properties of coarse aggregates

Max size of aggregates	Specific gravity	bulk density (Kg/m^3)	fineness modulus	Water absorption (%)
20 mm	2.85	1564.2	7.63	1.15
10 mm	2.83	1694.8	6.42	1.23

3.1.3. Water

Potable water was used for mixing and curing of specimens.

3.1.4. Super Plasticizer

To impart additional workability a super plasticizer AC-PLAST-BV-M4 conforms to IS: 9103-1999 was used in this experimentation.

3.1.5. Plastic fibers

The post consumed PET mineral water bottles were collected and the fibers were cut after removing the neck and bottom of the bottle. The length of fibers was kept 25 mm and the breadth was 1 mm and 2 mm. The aspect ratio (AR) of waste plastic fibers were 35 (AR-35) and 50 (AR-50).The plastic fibers used were having specific gravity 1.34 and water absorption 0.0%. The different fibervolume fractions for two aspect ratios were used in the experimentations.

3.2. Experimental Methodology

3.2.1. Concrete mix

Based on the trial mixes for different proportion of ingredients the final design mix was selected for M20 and M30 grade of concrete as per IS 10262:2009 [20], the concrete mix proportions are as given in the Table 4. The plastic fibers were added into dry mix of concrete in the percentages of 0.0 to 3.0% by weight of cement at the increment of 0.5% for compressive test and at an increment of 1.0% for sorptivity test.

Table 4 The concrete mix proportions

Grade of concrete	Cement (kg/m^3)	Fine aggregates (kg/m^3)	Coarse aggregates (10 mm) (kg/m^3)	Coarse aggregates (20 mm) (kg/m^3)	Water ($liter/m^3$)
M20	347	557	535.6	803.4	180.3
M30	376	535	534	801	180.3

3.2.2. Workability test

The workability of green concrete was determined with the help of slump cone test and compaction factor test for each percentage of plastic fibers. These tests were carried out at every batch of the concrete and average values were considered.

3.2.3. Cube compressive strength test

The cubical specimens of size 150 mm conforming to IS: 10086-1982 was tested to determine the compressive strength of concrete. The compressive strength test under compression testing machine of capacity 2000 kN was carried out as per IS: 516-1959 [21].

3.2.4. Sorptivity tests

For determining sorptivity, the standard test specimens of 101.6 mm diameter disc of thickness 50.8 mm were cast. These specimens were conditioned and tested as per ASTM C1585-4 [22] after 28 days of curing. The care was taken in conditioning specimens before the test to remove the internal moisture content. The conditioned test specimens were coated with an epoxy emulsion on their sides to prevent any water movement through the sides during the test, only unidirectional uptake of water from the bottom was permitted. The duration of test was for eight days. The schematic test set-up for sorptivity test was as shown in Figure 1.

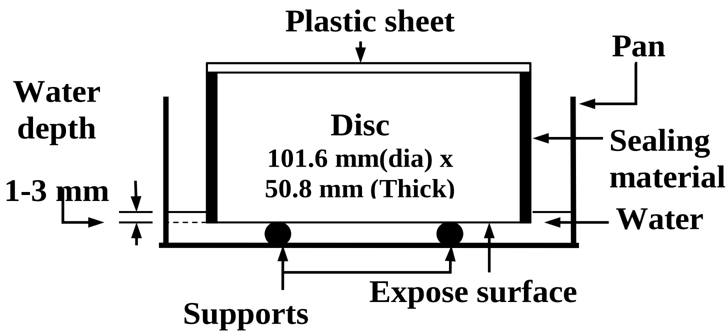

Figure 1 Schematic sorptivity test set-up

The absorption of water in millimeter is the change in mass of specimen divided by cross-sectional area of specimen and density of water. The density of water was taken 0.001g/mm3. The following Equation 1 was used for determining absorption of water in mm.

$$I = \frac{m_l}{a_e * d_w} \tag{1}$$

where,

I = the absorption in mm
m_l = the change in mass of specimen in grams, at time t,
a_e = the expose area in mm^2
d_w = the density of water in g/mm^3

The graphs, 'I' versus square root time, were plotted from the values obtained in the experiments. The slope of the line that is best fit for first six hours duration of water absorption is treated as initial rate of water absorption and the slope of the line that is best fit readings from one day to eight days is treated as secondary rate of water absorption. The Equations 2 and 3 were used for calculation of initial and secondary sorptivity, respectively.

$$I = S_i\sqrt{t} + b \tag{2}$$
$$I = S_s\sqrt{t} + b \tag{3}$$

where,

S_i = Initial sorptivity (initial rate of absorption) in mm/s$^{0.5}$
S_s = Secondary sorptivity (secondary rate of absorption) in mm/s$^{0.5}$
t = time in sec
b = a intercept obtained on 'I' axis

IV. Results And Discussions

The results of fresh and hardened concrete for normal concrete for two grades (M20 and M30) and two aspect ratios (AR) (35 and 50) are represented in Tables. The behavior of properties of waste plastic fiber reinforced concrete (PFRC) is shown in the form of graphs.

4.1. Workability

The following Table 5 shows the results of slump and compaction factor of normal concrete for M20 and M30 grades. The Figures 2 and 3 show the behavior of fresh PFRC in slump and compaction factor test results at different volume fractions. The workability of green concrete found decreases as fiber content increases in both tests, and it was due presence of fibers. It was observed that workability decreases for higher aspect ratio for both M20 and M30 grades. The more surface area of plastic fibers was available at higher aspect ratio, at same volume fraction, which causes an adhesion and holding of other ingredients of concrete.

Table 5 Slump, Compaction factor normal concrete

Grade of concrete	Slump (mm)	Compaction Factor
M20	83	0.913
M30	67	0.877

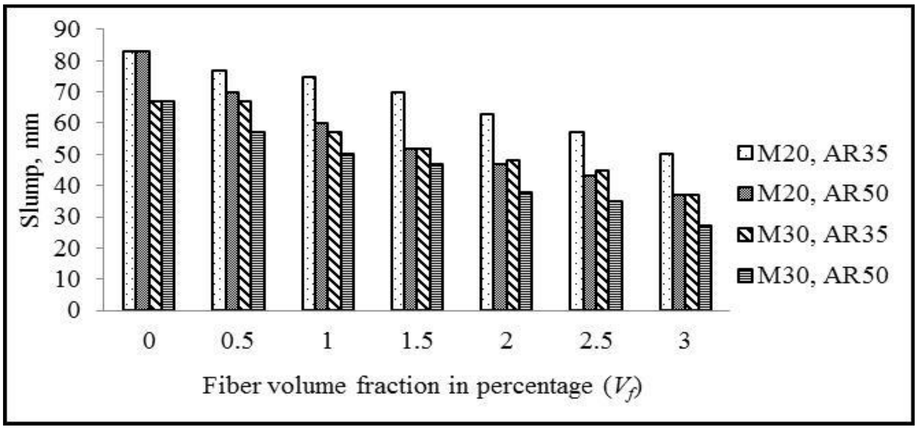

Figure 2 Slump in mm

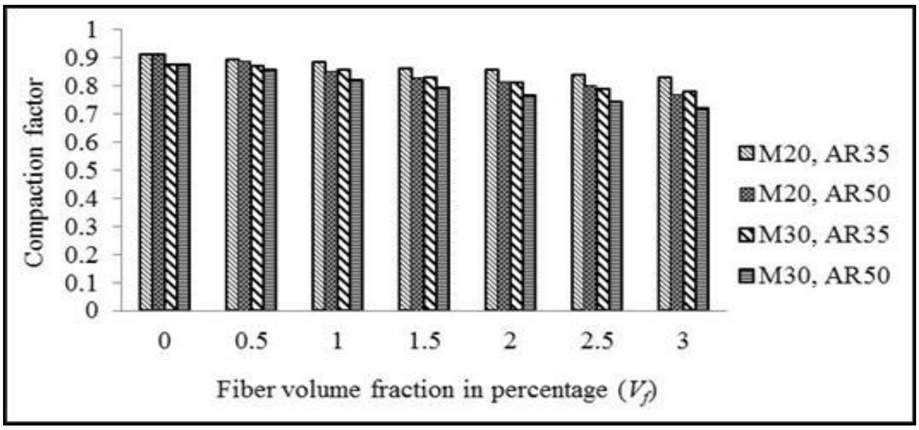

Figure 3 Compaction factor

4.2. Compressive Strength

The cube compressive strengths for NC and PFRC are reported in Table 6. The maximum increase in strength was observed at 1.0% of fiber volume fraction. The percentage change in cube compressive strength of concrete with respect to fiber volume fraction of plastic fibers is shown in Figure 4.

Table 6 Cube compressive strength of concrete

Mix	Average cube compressive strength in MPa	Mix	Average cube compressive strength in MPa
20NC	28.15	30NC	41.19
20M35-0.5	28.44	30M35-0.5	41.78
20M35-1.0	29.63	30M35-1.0	42.96
20M35-1.5	28.44	30M35-1.5	42.67
20M35-2.0	26.37	30M35-2.0	40.30
20M35-2.5	24.30	30M35-2.5	34.97
20M35-3.0	22.81	30M35-3.0	31.41
20M50-0.5	29.63	30M50-0.5	42.97
20M50-1.0	30.22	30M50-1.0	43.85

20M50-1.5	28.74	30M50-1.5	41.78
20M50-2.0	25.78	30M50-2.0	39.11
20M50-2.5	23.41	30M50-2.5	35.85
20M50-3.0	20.44	30M50-3.0	33.19

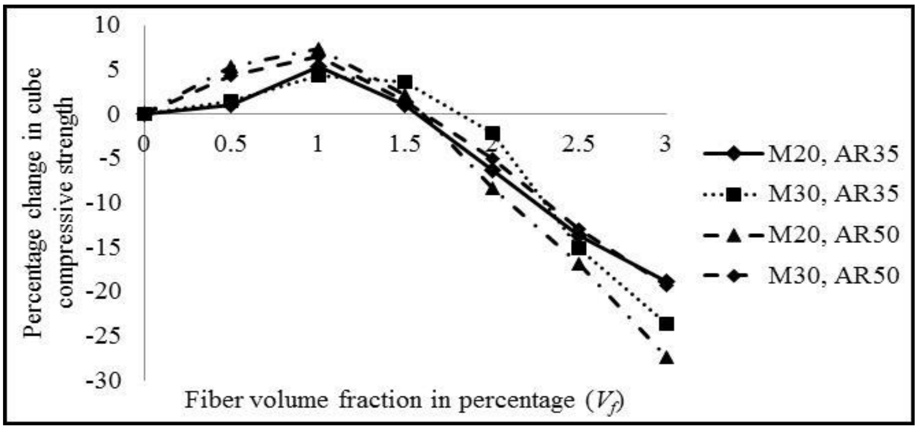

Figure 4 Percentage change in cube compressive strength

4.3. Sorptivity

The depth of water absorption was determined by using Equation 1. The sample graphs of depth of water absorption (I, mm) versus square root of time for a specimen of normal concrete (0%) and a specimen of M20 grade of concrete containing 1% fiber volume fraction of aspect ratio 35 are shown in Figures 5, from which initial and secondary sorptivity were determined by using Equations 3 and 4, respectively.

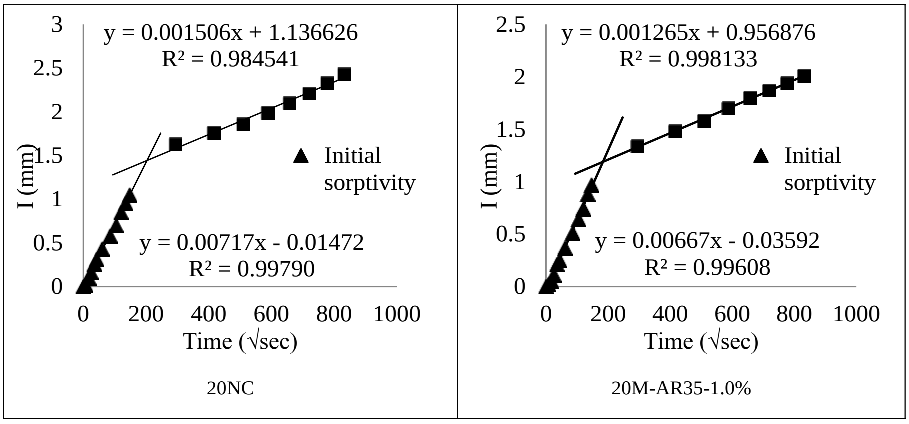

Figure 5 Water absorption in mm versus square root time

The initial and secondary sorptivity of concrete are reported in Tables 7 and 8. The maximum decreased in initial and secondary sorptivity are observed at 1.0 % fiber dose. The graphs of initial sorptivity of PFRC x square root of cube compressive strength of NC ($S_{if}\, x\sqrt{f_{cu}}$) versus fiber volume fraction are represented in Figure 6, and the graphs of secondary sorptivity of PFRC x square root of cube compressive strength of NC ($S_{sf}\, x\sqrt{f_{cu}}$) versus fiber volume fraction are represented in Figure 7.

Table 7 Initial sorptivity of concrete

Mix	Average initial sorptivity in 10^{-4} x mm/sec$^{1/2}$	Mix	Average initial sorptivity in 10^{-4} x mm/sec$^{1/2}$
20NC	72.40	30NC	61.65
20M35-1.0	65.99	30M35-1.0	55.30
20M35-2.0	68.63	30M35-2.0	57.50
20M35-3.0	74.52	30M35-3.0	62.42

20M50-1.0	63.82	30M50-1.0	53.83
20M50-2.0	68.15	30M50-2.0	58.54
20M50-3.0	75.94	30M50-3.0	63.40

Table 8 Secondary sorptivity of concrete

Mix	Average secondary sorptivity in 10^{-4} x mm/sec$^{1/2}$	Mix	Average secondary sorptivity in 10^{-4} x mm/sec$^{1/2}$
20NC	14.68	30NC	12.64
20M35-1.0	12.83	30M35-1.0	10.73
20M35-2.0	14.21	30M35-2.0	12.42
20M35-3.0	15.42	30M35-3.0	13.13
20M50-1.0	12.21	30M50-1.0	10.44
20M50-2.0	14.38	30M50-2.0	12.82
20M50-3.0	15.75	30M50-3.0	13.32

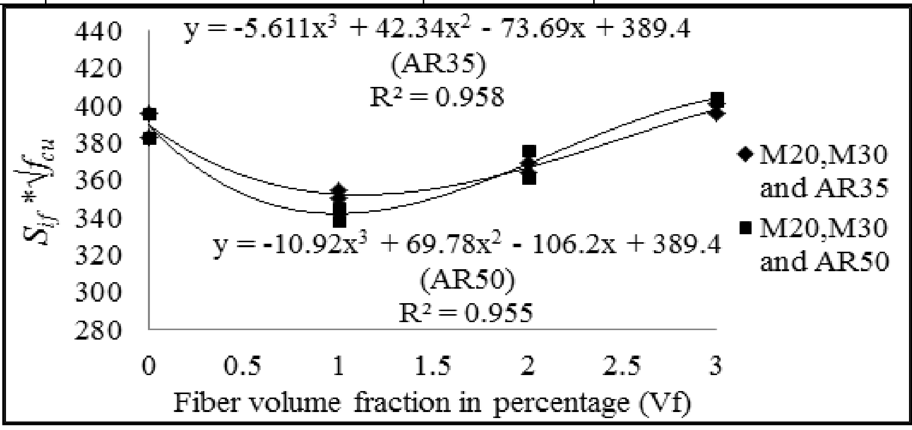

Figure 6 Initial sorptivity of PFRC x compressive strength of NC versus Vf

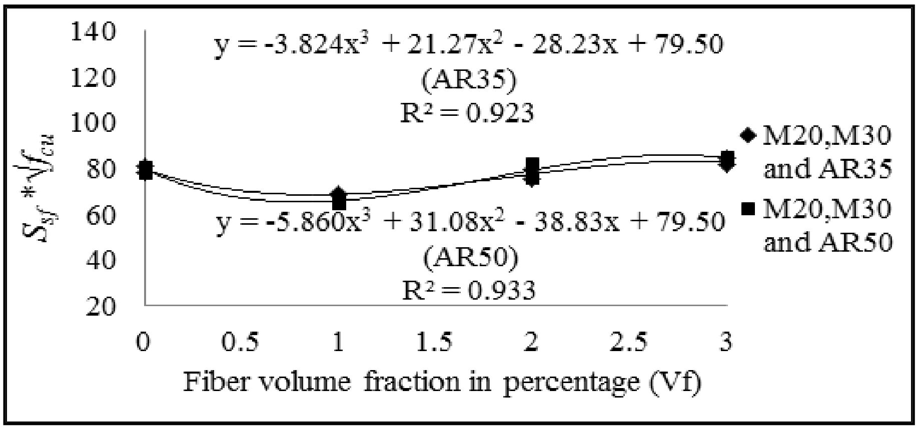

Figure 7 Secondary sorptivity of PFRC x compressive strength of NC versus Vf

1. Mathematical model for prediction of initial sorptivity (10^{-4} mm/$\sqrt{s}$) of PFRC (Figure 6)

$$S_{if} = \frac{1}{\sqrt{f_{cu}}}\left(-5.611V_f^3 + 42.34V_f^2 - 73.69V_f + 389.4\right), [AR-35] \quad (4)$$

$$S_{if} = \frac{1}{\sqrt{f_{cu}}}\left(-10.92V_f^3 + 69.78V_f^2 - 106.2V_f + 389.4\right), [AR-50] \quad (5)$$

2. Mathematical model for prediction of secondary sorptivity (10^{-4} mm/$\sqrt{s}$) of PFRC (Figure 7)

$$S_{sf} = \frac{1}{\sqrt{f_{cu}}}\left(-3.824V_f^3 + 21.27V_f^2 - 28.23V_f + 79.50\right), [AR-35] \quad (6)$$

$$S_{sf} = \frac{1}{\sqrt{f_{cu}}}\left(-5.860V_f^3 + 31.08V_f^2 - 38.83V_f + 79.50\right), [AR-50] \quad (7)$$

The experimental average values and corresponding predicted values (Equations 4 and 5) of initial sorptivity, and the experimental average values and corresponding predicted values (Equations 6 and 7) of secondary sorptivity of PFRC are presented in Table 9. The validity of experimental values with 90 to 95% confidence for initial and secondary sorptivity is shown in Figure 8 and Figure 9 respectively.

Table 9 Experimental and predicted values of initial and secondary sorptivity

Sr. No.	Mix	Initial sorptivity (10^{-4} mm/√s)			Secondary sorptivity ((10^{-4} mm/√s))		
		Expt. Values	Predicted values	% difference in expt. values w.r.t. predicted	Expt. Values	Predicted values	% difference in expt. values w.r.t. predicted
1	20NC	72.24	73.39	-2	14.68	14.98	-2
2	20M35-1.0	65.99	66.43	-1	12.83	12.95	-1
3	20M35-2.0	68.63	69.08	-1	14.21	14.61	-3
4	20M35-3.0	74.52	74.99	-1	15.42	15.64	-1
5	20M50-1.0	63.82	64.47	-1	12.21	12.49	-2
6	20M50-2.0	68.15	69.50	-2	14.38	15.09	-5
7	20M50-3.0	75.94	76.14	0	15.75	16.15	-3
8	30NC	61.65	60.67	2	12.64	12.39	2
9	30M35-1.0	55.3	54.91	1	10.73	10.71	0
10	30M35-2.0	57.5	57.10	1	12.42	12.08	3
11	30M35-3.0	62.42	62.00	1	13.13	12.93	2
12	30M50-1.0	53.83	53.30	1	10.44	10.33	1
13	30M50-2.0	58.54	57.46	2	12.82	12.48	3
14	30M50-3.0	63.40	62.95	1	13.32	13.35	0

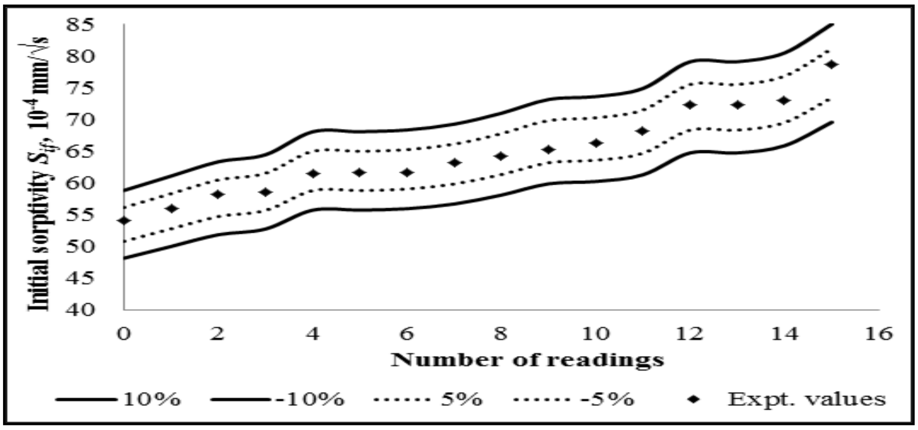

Figure 8 Validity of mathematical model (Eq. 4, 5) with 90% to 95% confidence

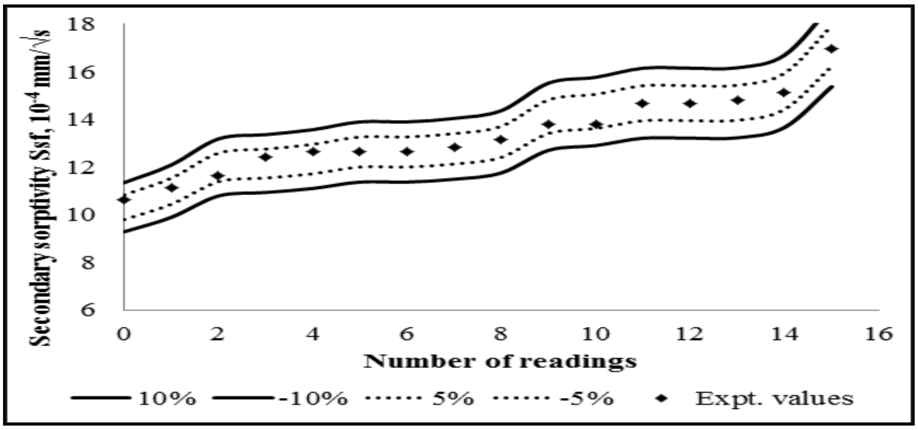

Figure 9 Validity of mathematical model (Eq. 6, 7) with 90% to 95% confidence

V. CONCLUSIONS

The results of this investigation can be summarized as follows.

1) The behaviour of green concrete under slump and compaction factor tests shows that workability is reduced in PFRC. It was due to resistance offered by the fibers to the movement of aggregates.
2) It was observed, during compressive strength test, that normal concrete specimens were suddenly broken into pieces but PFRC specimens did not suddenly break and failure was ductile.
3) The little improvement in compressive strength of plastic fiber reinforced concrete was observed, the improvement was observed from 0.0% to 1% volume fraction of plastic fibers and at higher volume fraction of fibers, reduction in compressive strength were observed. The maximum increase in compressive strength at 1.0% fiber volume fraction for M20 grade of concrete at aspect ratio 50 is 7.35% respect to normal concrete.
4) The sorptivity of PFRC is decreased at 1% fiber volume fraction and thereafter increased at higher volume fraction for both grades of concrete (M20 and M30) and both aspect ratios (35 and 50). It is observed that initial and secondary sorptivity of PFRC of M20 grade at 1% fiber dose of aspect ratio 50 are reduced to 11.85% and 16.83%, respectively.
5) The equations proposed in the study for prediction of properties of PFRC works within 90% confidence limit.
6) The observations are the evidence of inclusion of unprocessed plastic fibers, obtained from waste mineral water bottles, helps to improve the mechanical properties of concrete which is an innovative low cost material that can be promote in construction field to resolve some of the solid waste problems and preventing environment pollution also.

Scope for future study

The present study has good scope for further research. Some research areas may be as follows:

1) The properties like shrinkage and creep of PFRC can be evaluated.
2) Properties of PFRC for higher grades of concrete can be study.
3) Resistance to chemical attack need to be study.
4) PFRC with crushed sand and recycled aggregates.
5) Combination with different origin fibers with plastic fibers in concrete.
6) Different aspect ratios of fibers, different shape of fibers can be study.
7) Machine can be design for cutting of fibers from PET bottles

REFERENCES

[1] Batayneh M., Marie I., Asi I., "Use of selected waste materials in concrete mixes." Waste Management, Vol.27, pp. 1870–1876, 2006.
[2] Soroushian P., Mirza F., Alhozaimy A., "Permeability characteristics of polypropylene fiber reinforced concrete." ACI Materials Journal, Vol. 92, No. 3, pp. 291–295, 1995.
[3] Ismail Z.Z., Al-Hashmi E.A., "Use of waste plastic in concrete mixture as aggregate replacement." Waste Management, Vol. 28, No. 11, pp.2041-2047, 2008.
[4] Al-Manaseer A.A., Dalal T.R., "Concrete containing plastic aggregates." Concrete International, Vol. 19, No. 8, pp. 47– 52, 1997.
[5] Choi Y.W., Moon D.J., Chung J.S., Choi S.K. 2005. "Effects of waste PET bottles aggregate on properties of concrete." Cement and Concrete Research, Vol. 35, pp. 776–781.
[6] Marzouk O. Y., Dheilly R.M., Queneudec M., "Valorization of post-consumer waste plastic in cementitious concrete composites." Waste Management, Vol. 27, pp. 310–318, 2007.
[7] Ochi T., Okubo S., Fukui K., "Development of recycled PET fiber and its application as concrete-reinforcing fiber." Cement and Concrete Composites, Vol. 29, pp. 448-455, 2007.
[8] Kim Sung Bae, Kim Na Hyun Young, Kim Jang-Ho Jay, Song Young-Chul, "Material and structural performance evaluation of recycled PET fiber reinforced concrete." Cement and concrete composites, Vol. 32, pp. 232-240, 2010.
[9] Foti Dora, "Preliminary analysis of concrete reinforced with waste bottles PET fibers." Construction and building materials, Vol. 25, pp. 1906-1915, 2011.
[10] Pelissera Fernando, Montedoa Oscar Rubem Klegues, Gleizeb Philippe Jean Paul, Romanb Humberto Ramos, "Mechanical properties of recycled pet fibers in concrete", Materials Research, Vol.15, No. 4, pp. 679-686, 2012.
[11] Shamskia N., "The influence of pet fibers on the properties of fresh and hardened concrete", Journal of Structural Engineering and Geotechnics, Vol. 2, No. 1, pp.13-17, 2012.

[12] Afroz Mahzabin, Hasan Mohammad Jobaer, Islam Md.Nazrul, Rashid Muhammad Harunur, Hossain Md.Akhtar, , "Performance of pet bottle fiber to enhance the mechanical behavior of concrete", http:// www.civil.mrt.ac.lk / conference / icsecm _2011 / sec-11-28.pdf, 2011 (accessed on 23/04/2013).
[13] Nibudey R. N., Nagarnaik P. B., Parbat D. K., Pande A. M., "Strengths prediction of plastic fiber reinforced concrete (M30)", International Journal of Engineering Research and Applications, Vol. 3, No 1, pp.1818-1825, 2013.
[14] Nibudey R. N., Nagarnaik P. B., Parbat D. K., Pande A. M., "Strength and fracture properties of post consumed waste plastic fiber reinforced concrete", International Journal Of Civil, Structural, Environmental And Infrastructure Engineering Research And Development, 3(2), 2013, pp. 9-16.
[15] Nibudey R. N., Nagarnaik P. B., Parbat D. K., Pande A. M., "A model for compressive strength of PET fiber reinforced concrete", American Journal of Engineering Research, Vol. 2, No. 12, pp367-372, 2013.
[16] Nibudey R. N., Nagarnaik P. B., Parbat D. K., Pande A. M., "Cube and cylinder compressive strengths of waste plastic fiber reinforced concrete", International Journal of Civil and Structural Engineering, Vol. 4, No. 12, pp.174-182 , 2013.
[17] Sara Soleimanzadeh and Md Azree Othuman Mydin, "Influence of Fly Ash and Densified Silica Fume as Additives on Mechanical Properties of Coir Fiber Reinforced High-Strength Concrete", International Journal of Advances in Engineering & Technology, Vol. 4, Issue 2, pp. 538-546, 2012.
[18] IS 1489-1:1991(R2005). "Portland-Pozzolana Cement - Specification - Part 1: Fly ash based." Bureau of Indian Standard Institution, New Delhi.
[19] IS: 383-1970. "Indian standards specification for coarse and fine aggregates from natural sources for concrete." Bureau of Indian Standard Institution, New Delhi.
[20] IS: 2386-1963. "Indian standards code of practice for methods of test for Aggregate for concrete." Bureau of Indian Standard Institution, New Delhi.
[21] IS: 10262:2009. "Recommended guidelines for concrete mix design." Bureau of Indian Standard Institution, New Delhi.
[22] IS: 516-1959 (reaffirmed 1999) Edition 1.2 (1991-07). "Methods of tests for strength of concrete." Bureau of Indian Standard Institution, New Delhi.
[23] ASTM Standard Designation C1585-4, 2004. "Standard test method for measurement of rate of absorption of water by hydraulic-cement concretes." Annual book of ASTM standards, Pennsylvania, United states.

AUTHOR'S BIOGRAPHY

R. N. Nibudey is working as a lecturer (Selection Grade) in Applied Mechanics Department at Government Polytechnic, Gondia (Maharashtra). He is Life Member Institution of Engineers (I), Life Member of Indian Society for Technical Education (ISTE). He is awarded by Certificate of Excellency in testing by Director of Technical Education, Maharashtra State. His research interests include fiber reinforced concrete and testing of building materials.

P. B. Nagarnaik is working as Professor in Civil Engineering Department, Deputy Director and Dean Academics at G. H. Raisoni College of Engineering, Nagpur (Maharashtra). His research interests include fiber reinforced concrete and Environmental Engineering.

D. K. Parbat is working as a lecturer (Selection Grade) in Civil Engineering Department at Government Polytechnic, Sakoli (Maharashtra). He is awarded Best Polytechnic Teacher (State Level) by ISTE and Government of Maharashtra. His research interests include fiber reinforced concrete and Transportation Engineering.

A. M. Pande is working as Professor in Civil Engineering Department and Director R&D, at Yeshwantrao College of Engineering, Nagpur (Maharashtra). He is Member Institution of Engineers (I), Member of Indian Society for Technical Education.(ISTE), Member Indian Concrete Institute , Member BIS Committee CED. His research interests include fiber reinforced concrete and research related activities.