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A Review on the Use of Waste PET Fibre as a Supplement of Aggregate in Concrete

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Abstract—*Plastic waste is a serious environmental threat to the modern way of living. According to the latest study of 2018, 70% of total plastic consumption is discarded as waste in India. The improper disposal of plastic bottle has been a major concern to the environment as it is not easily degradable. Now-a-days research on usage of innovative material in concrete has increase to a large extent. Therefore, one of the solution to this problem is to recycle polyethylene terephthalate (PET) in the construction industry as fibre concrete (FC).*

This paper reviews various studies conducted by various researchers on PET fibres in concrete. The objective of this study is to determine the mechanical properties and the optimum percentages of recycled PET fibres in OPC concrete. In this study, straight and irregular recycle PET fibres were used. The fibres were cut from waste plastic bottles in different dimensions ranging from 50mmX5mm to 10mmX1mm.These fibres were used to replace cement, fine aggregate and coarse aggregate to a certain percentage. The fibres were reinforced as a partial replacement of 0.25%, 0.5% and 0.75% of weight of cement; 0.5%, 1% and 1.5% of weight of fine aggregate; and 5%, 10%, 15% and 20% of weight of coarse aggregate. Tests like compressive strength test, splitting tensile strength test, flexural strength test and slump cone test were conducted. The specimens were tested after 28 days. Finally, the results of the fibre reinforced concrete shall be compared with the conventional concrete.

1. Introduction

Concrete is most frequently used man made versatile material comprising of cement, fine aggregate, coarse aggregate and water in a definite proportion. Concrete is widely used as a construction material all over the world due to its high compressive strength, long service life, fire resistance, durable and low cost but the tensile strength of concrete is very low. The tensile strength as well as ductile property of concrete could be improved by addition of fibres. Today the construction industry is in need of finding cost effective materials for increasing the strength of concrete structures. To improve the properties of concrete, numerous studies on fibre concrete (FC) have been performed. This resulted in the idea of making use of one of the most common waste i.e. plastics such as polyethylene terephthalate bottles (PET) to produce fibre concrete (FC). FC enhances crack control and ductility in quasi- brittle concrete and can be an alternative for mass consumption which is an important issue in recycling waste material. This project deals with the possibility of using the waste (PET) bottles as the partial replacement of aggregate in plain concrete.

Plastic waste is increasing to a large extent day by day. About 300 million tons of plastic is produced globally each year. Only about 10% of that is recycled .Of the plastic that is simply trashed, an estimated seven million tons ends up in the sea each year. In order to reduce the contamination of environment with such waste materials, various researchers have introduced new ways to reuse waste materials in the field of construction. They have performed several experiments on the use of innovative material in concrete to increase its characteristics. A large portion of plastic waste is shared by a type of plastic waste known as Polyethylene Terephthalate most commonly known as PET.

Polyethylene Terephthalate (PET) is a thermoplastic polymer resin of the polyster family and is used in synthetic fibres. It is one of the most important and extensively used plastic in the world especially for manufacturing plastic bottles used as containers for food, soft drink, beverage and water. Since it is a non biodegradable waste, its improper disposal is quite harmful to our health. To solve this problem researchers have come up with the idea of utilizing and reusing it in construction industry extensively.

PET bottles in fibre form can be used to get better mechanical strength of concrete. According to the experiments conducted by various researchers, it has been found that the tensile strength and ductility of concrete can be increased by introducing PET fibre of different dimensions in concrete.

This review paper reports the properties of concrete when waste PET fibre is reinforced as a supplement of aggregate in reinforced plain concrete. The objective of this paper is to study and analyze the different experimental case studies

based on researches, experimental works and scientific reports to determine the improvement in the properties of PET fibre reinforced concrete in comparison to conventional concrete. The use of PET fibre in concrete not only reduces the pollution of waste plastic bottle but also serve as an effective means of producing highly economic and sustainable building material in future.

2. Materials Used

The materials used in different experiment by different researchers are as follows-[1 to 24]

-Plastic fibers: PET fibers of different forms and dimensions.

- Cement: OPC 53 grade and 43 grade.

- Fine aggregate: River sand.

- Coarse aggregate: Ranges from 20mm to 12.5mm.

- Water: Potable water.

- Super plasticizers: Super plasticizers are sometimes used to increase the workability of concrete.

3. Methodology

3.1 Properties of Polyethylene Terephthalate fibers:

PET is a hard , stiff, strong and dimensionally stable material that is usually used as packaging for carbonated beverages, water and many food products. Its crystallinity varies from amorphous to fairly high crystalline. PET is found to be effective in replacing aggregates in concrete because of its versatile behaviour (it is lightweight, flexible, strong, moisture- resistant and cheap).

3.2 PET fibre preparation:

PET plastic bottles were collected, cleaned and dried before being cut into fibre form to get rid of any impurities. They were cut into smaller pieces into the desired shape and size.

3.3 Concrete Mix Design:

Ramadevi et.al. [1] used M25 grade concrete. R.N. Nibudey et.al. [2] used M30 grade concrete. Balte Sanjaykumar et.al. [3] used M20 grade concrete. Mastan Vali N et.al. [4] used M30 grade concrete.

Table 1: Specimen dimensions

Type of Test	Dimension of mould
Compressive Strength Test	150*150*150mm
Split Tensile Strength Test	300*150mm
Flexural Strength Test	150*150*750mm

4. Test on specimen

Test on Fresh Concrete:

A) Workability

Test on Hardened Concrete:

A) Compressive Strength Test
B) Flexural Strength Test
C) Split Tensile Strength Test

5. Experimental Findings of different researchers

A review of the work carried out by different researchers in the field of using recycled waste plastic in concrete are discussed below.

Ramadevi et.al.[1] performed experiments on replacement of fine aggregate with 0.5%, 1%, 2%, 4% and 6% of PET fibre in fibre reinforced concrete. The author revealed an increase in compressive and tensile strength as compared to conventional concrete.

R.N. Nibudey et.al.[2] optimized the benefits of using post consumed waste PET bottles in the fibre form in concrete. The author used PET fibre of aspect ratios 30 and 50 to determine the properties of green and hardened concrete. It was observed that slump, compaction factor and dry density of concrete reduces as compared to normal concrete when fibre content increases and reduction in these values found higher for larger value of aspect ratio.

Balte Sanjaykumar et.al.[3]

He conducted various experiments using PET fibre of dimension 35mm*1mm and aspect ratio 35.

In his experiment, 0.5%, 1%, 1.5% and 2% of fine aggregate was replaced by PET fibre.

The specimen was tested for compressive strength, flexural strength and split tensile strength test after 3, 7 and 28 days of curing.

He concluded that the introduction of PET bottle fibre in concrete helps it to hold its ingredients together.

Aditya Krishna Reddy et.al.[4]

In his study, the PET fibres were in the form of short strip and its surface was coated with maleic anhydride grafted polypropylene. O shape fibre were also used as it improves the mechanical properties of concrete than those fibre in the form of short strips.

The percentage replacement of PET fibre were 0.25%, 05%, 0.75% by weight of cement and superplasticizers of 0.8% by weight of cement.

The dimension of the O shape ring fibre were of 5 to 7mm width, 100mm diameter and 0.6mm thickness.

Dora Foti [5]

The PET fibre used were in the form of O-shape with 60mm diameter and 5mm width, and short lamellar fibres having 35mm length and 5mm width.

The test have shown that the addition of a very small amount of fibre from recycled and shredded PET bottles can have large influence on the post cracking behavior of plain concrete elements.

Introduction of PET fibre in concrete increases the ductility too.

Both lamellar and 'O' shape fibres greatly improve the toughness of the specimen. The enhancement of the toughness is especially evident for the 'O' fibre and it seems that their special shape helps to bind the concrete on each side of a cracked section.

Semiha Akcaozoglu et,al.[6]

The size of shredded PET granules used in the preparation of mortar were between 0mm and 4mm.

The use of shredded waste PET granules due to its low unit weight reduces the unit weight of concrete which results in a reduction in the dead weight of a structural concrete member of a building.

It was concluded that there is a potential for the use of shredded waste PET granules as aggregate in the production of structural lightweight concrete.

The study concluded that the use of industrial waste such as PET granules and blast- furnace slag in concrete provides some advantages i.e. reduction in the use of natural resources, disposal of wastes, prevention of environmental pollution and energy saving.

G. Murali et.al.[7]

In his study, he used soft drink bottle cap, empty waste tin lathe waste, waste steel powder in 1% of total weight of concrete as fibers.

The waste materials mentioned above were deformed into rectangular strips of 10mm length and 3mm breadth.

Ganesh Prabhu et.al.[8]

In this study the PET fibres were used in three different dimensions of aspect ratios 17 i.e.(50mm*3mm), 33 i.e. (100mm*3mm) and 50 i.e. (150mm*3mm).

The replacement were 0.5%, 1% and 1.5% of fine aggregate for 3, 7 and 28 days.

Divya Prabha V.M.et.al. [9]

The aspect ratios of PET fibre used in this study were 4(8mm*2mm), 8(16mm*2mm) and 12 (24mm*2mm) with 0.5%, 1% and 1.5% replacement of aggregate.

Compressive, shear and flexural strengths increase with increased in percentage of PET fibre.

Replacement of fine aggregate with 2%, 4% and 6% of PET fibre in concrete.

From the experiment, it shows that the percentage of PET replaced, the compressive strength of concrete decreases.

The density decrease when PET content increase.

6. Observation and Result

It was observed that there is an appreciable amount of increase in compressive strength till 2% replacement of fine aggregate with PET fibres and then compressive strength gradually reduced with increase in percentage of fibre. Split tensile strength increases till 2% replacement of fine aggregate with PET fibres and then decreases slightly with increase in the replacement of fine aggregate.Flexural strength increases with increased in percentage of replacement but its value falls with more percentage of replacement.[1]

From the test, it was observed that the results of compressive , split tensile and flexural strength test of 1% of fibre content showed higher improvement in strength for AR 50 than AR 30.[2]

It was observed that the tensile strength was maximum with 1.5% replacement of fine aggregate. Upto 4% to 5% compressive strength from that of conventional concrete was increased with addition of PET fibre in concrete. 59% flexural strength was increased with addition of PET fibres in concrete.[3]

The compressive strength was increased upto 0.75% replacement. Split tensile strength was increased by 20.3% with 0.75% replacement of cement as compared to that of plain concrete after 28 days of curing.

Flexural strength was increased by 35% with 0.75% replacement of cement as compared to that of plain concrete.[4]

The test result showed that the ductility of concrete was increased with reinforcement of PET fibre in plain concrete. The 'O' shape fibre greatly improved the toughness of concrete.[5]

The compressive strength was increased upto 28.3MPa with the introduction of shredded PET granules in concrete. The flexural strength was increased upto 4.8MPa with the introduction of shredded PET granules in concrete.[6]

The specimen with steel powder as waste material was found to be good in compression which had the compressive strength of 41.25% more than the conventional concrete. Better split tensile strength was achieved with the addition of the steel powder waste in concrete. The strength has increased upto 40.87% when compared to that of the conventional concrete specimen. In flexure the specimen with soft drink bottle caps as waste material was found to be good. While adding the soft drink bottle caps the flexural strength increased by 25.88% that of the conventional concrete.[7]

In all the cases i.e. 05%, 1% and 1.5% replacement and AR 17, 33 and 50, the compressive strength and tensile strength is greater than compressive strength and tensile strength of conventional concrete, but tensile strength of AR 50 decreases from conventional concrete.

The optimum strength was observed at 1% of fibre content for all type of strength. It was seen from the experiment that development in strength was higher for AR 33. From this study, it was observed that upto 30% to 35% strength of concrete was increased.[8]

From the experiment, it was observed that conventional concrete specimen fail suddenly at ultimate strength whereas fibre reinforced concrete (FRC) specimen did not fail suddenly. FRC of AR 4 with 2% PET fibre content was seen to be the most reasonable one.[9]

7. Advantage of PET fibre in concrete

A) Light weight than competing materials.
B) Durable and longevity.
C) Resistant to chemical, water and impact.
D) Excellent thermal and electrical insulation property.
E) Comparatively lesser production cost.

8. Conclusion

From the results of previous authors, the following conclusion can be drawn:

A) Use of PET bottle fibre in the form of 'O' shape is more preferable than lamellar fibre as it gives better result.
B) Replacement of fine aggregate up to 2% gives satisfying result for compressive, split tensile and flexural strength.
C) PET bottle fibres cut into a dimension of 100mm*3mm and aspect ratio 33 shows good result of most of the strength test.
D) The introduction of waste PET bottle fibre increases the split tensile strength, flexural strength and ductility of the fibre reinforced concrete (FRC) to a large extent.
E) With the addition of waste PET bottle fibre in plain concrete, most of the properties of concrete can be improved.

Therefore, it can be concluded that with the increasing demand of aggregate in today's construction industry, the replacement of aggregate with waste materials like PET bottle fibre may be encouraged. This will lead to economical construction compared to normal construction materials. Moreover, there will be reduction in the pollution of the surroundings which will help in providing eco- friendly and sustainable environment.

Reference

[1] K. Ramadevi, R. Manju " Experimental investigation on the properties of concrete with plastic PET bottle fibre as fine aggregates" Interntional Journal of Emerging Technology and Advanced Engineering (ISSN 2250-2459, Volume 2, Issue 6, June 2012)

[2] R. N. Nibudey, P.B. Nagarnaik, D.K. Parbat, A.M. Pande " Compressive trength and sorptivity properties of PET fiber reinforced concrete" *International Journal of Advances in Engineering & Technology*, Sept., 2014. ©IJAET 1206 Vol. 7, Issue 4, pp. 1206-1216 ISSN: 22311963

[3] Balte Sanjaykumar, S.N. Daule " Use of plastic fibre in the concrete *SSRG International Journal of Civil Engineering* (SSRG-IJCE)- Volume 4 Issue 11- November 2017

[4] Aditya Krishna Reddy., Arun Kumar "Study of Mechanical Properties of Concrete using Waste Pet Bottle Fibres for the Reinforcement*" International Journal of Engineering and Management Research* Volume-4, Issue-2, April-2014, ISSN No.: 2250-0758

[5] Dora Foti, "Preliminary analysis of concrete reinforced with waste bottles PET fibers", *Construction and Building Materials*, Volume 25, Issue 4, April 2011, Pages 1906–1915

[6] Akçaözoğlu S, Atiş CD, Akçaözoğlu K, "An investigation on the use of shredded waste PET bottles as aggregate in lightweight concrete", *Waste Management*. 2010 Feb;30(2):285-90. Epub 2009 Oct 22.

[7] G.Murali, C.M.Vivek Vardhan, R.Prabu, Z.Mohammed Sadaquath Ali Khan, T.Aarif Mohamed and T.Suresh, " Experimental investigation on fibre reinforced concrete using waste materials", *International Journal of Engineering Research and Applications (IJERA)* ISSN: 2248-9622 www.ijera.com Vol. 2, Issue 2,Mar-Apr 2012, pp.278-283

[8] P.Ganesh Prabhu, C.Arun Kumar, R.Pandiyarj, P.Rajesh & L.Sasi Kumar " Study on Utilization of Waste PET Bottle Fibre in Concrete". IMPACT: *International Journal of Research in Engineering and Technology (IMPACT:IJRET)* ISSN(E):2321-8843; ISSN(P):2347-4599 Vol.2, Issue 5,May 2014, 233-240.

[9] Divya Prabha V M, Dr. Sunilaa George " Shear Behavior of Reinforced Concrete Using PET Bottle Fibre*". International Journal of New Technology and Research (IJNTR)* ISSN:2454-4116, Volume-3, Issue 5, May 2017 Pages 54-56. M.

[10] M. Mokhtar, M. Kaamin, S. Sahat, and N.B. Hamid" The Utilisation of Shredded PET as Aggregate Replacement for Interlocking Concrete Block*" E3S Web of Conferences* 34, 01006 (2018)

[11] S.Shahidan, N.A.Ranle, S.S. Mohd Zuki, F. Sheikh Khalid, A.R.M. Ridzuan, F.M. Nazri." Concrete Incorporated with Optimum Percentage of Recycled Polyethylene terephthalate (PET) Bottle Fibre." *International Journal of Integrated Engineering* Vol.10 No.1(2018)p.1-8.

[12] Comingstarful Marthong , Deba Kumar Sarma " Mechanical Behaviour of Recycled PET Fiber Reinforced Concrete Matrix" *World Academy of Science, Engineering and Technology International Journal of Civil and Environmental Engineering* Vol:9, No:7,2015.

[13] Nancy L. Holland, John M. Nichols and Anne B. Nichols " Fibre Reinforced Concrete Using Polyethylene Strips" *BEFIB2012-Fibre reinforced concrete Joaquim Barros et al (Eds) UM, Guimaraes,* 2012.

[14] Vikas Thakur, Jagdish Kamboj "A Review On Study Of Mechanical Properties Of Concrete Using Coated Pet Fibers " *International Research Journal of Engineering and Technology (IRJET)* e-ISSN: 2395-0056, Volume: 05 Issue: 02 | Feb-2018

[15]Sagar Bagde, B.J.Wasnik, K.G.Raut" Performance of Fiber Reinforced Concrete from Recycled Pet Plastic Waste- A Study Review" *International Journal for Research in Applied Science & Engineering Technology(IJRASET)* Volume 5 Issue IV, April 2017 IC Value: 45.98 ISSN: 2321-9653©IJRASET

[16] Salahaldein Alsadey " Utilization of Plastic Bottle Waste in Concrete" *Journal of Biological and Environmental Engineering* Vol. 1, No. 1, 2016, pp. 1-5

[17]Venu Malagavelli , Rao.P.N "Effect of non bio degradable waste in Concrete slabs" *International Journal Of Civil And Structural Engineering.* Volume 1, No 3, 2010 Research article ISSN 0976 – 4399

[18] Vinod L. Patil, Vivek Shukla "Use Of Pet Fibre As Constituent Of Concrete" *IJARIIE*-ISSN(O)-2395-4396. 280 www.ijariie.com 280 Vol-3 Issue-2 2017

[19] Nilesh S.Badave, Dr.Chetan P.Pise "Study on Effect of Waste Polyethylene Terephthalate Bottle Fibers on Silica Fume Concrete – A Review" *International Journal of Scientific & Engineering Research* Volume 9,Issue2,February-2018 2046 ISSN 2229-5518

[20] M. Mokhtar, M. Kaamin, S. Sahat, and N.B. Hamid " The Utilisation of Shredded PET as Aggregate Replacement for Interlocking Concrete Block" *E3S Web of Conferences 34*, 01006 (2018)

[21] Zainab Z. Enas A. AL-Hashmi, Ismail " Use of waste plastic in concrete mixture as aggregate replacement", *Waste Management*, Volume 28, Issue 11, November 2008, Pages 2041–2047

[22] Venu Malagavelli, Rao.P.N, "Effect of non bio degradable waste in Concrete slabs", *International Journal of Civil and Structural Engineering*, Volume 1, No 3, 2010

[23] Youjiang Wang H.C.Wu and Vitor C.Li (2000) ,"Concrete Reinforcement with Recycled Fibers", *Journal of Materials In Civil Engineering* / November 2000

[24] R.Kandasamy and R.Murugesan(2011), "Fibre Reinforced Concrete Using Domestic Waste Plastics as Fibres", *ARPN Journal of Engineering and Applied Sciences*, Volume 6, No.3, ISSN 1819- 6608