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EXPERIMENTAL RESEARCH ON CONCRETE WITH STRAIGHT AND CRIMPED WASTE PLASTIC FIBRES

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ABSTRACT

Concrete is the most broadly used construction material in the world due to its compressive strength, extended service life, and low cost. This experimental program seeks to optimize the benefits of using straight and crimped fibres, from waste polyethylene terephthalate (PET) bottles. As plastic is non biodegradable, its disposal has been a problem. To address this issue, the fibres from post consumed waste plastic bottles were added in different percentages in the M30 grade concrete. The post consumed waste plastic bottles were shredded into fibres of specific size and shape. An experimental investigation was carried out on the specimen's cubes, cylinders and beams which were cast in the laboratory and their behaviour under the test was observed. The plastic fibres were added from 0 % to 1.5 % for three aspect ratios. The slump test, compressive, split tensile strength and flexural strength tests were performed on the concrete after 28 days of curing phase. The test results obtained were compared with control specimen and the results were plotted in the form of graph. The solution offered in the project is one of the answers to long standing menace of waste disposal.

KEY WORDS: *Poly Ethylene Terephthalate Fibres, Fibre Reinforced Concrete, Strength Parameters*

I. GENERAL

A new revolution, a new movement, a new awareness is spreading across the world. Governments and organizations are working together to find solutions for a greener future, while prospective zero – carbon sustainable cities are already underway. The introduction of fibres was brought in as an alternative to developing concrete in view of enhancing its flexural and tensile strengths. The major advantage of using fibre reinforcement concrete is to convert a brittle concrete into a pseudo ductile concrete. The fibres introduction in cement matrix behaves as an unwanted micro crack arrester which in turn causes gradual failure.

The plastic waste is a serious environmental threat to modern civilization. Since plastic is a non-biodegradable material, land-filling using plastic would mean preserving the harmful material forever. Attempting to experiment by using and recycling waste materials, PET (Poly Ethylene Terephthalate) bottles which normally end up in landfills is used as a construction material. It takes an average of 300 years for a plastic bottle to completely disintegrate into the ground, during which time a substantial amount of toxins and chemicals are released into the earth.

The fibres developed thorough recycling process are costly that's why the fibres are shredded into required shape and size. The structures built using waste materials, have taught lessons about the economic value of such materials and the utility of recycling them. This is an effective solution for reusing the plastic. The PET fibres inclusion in concrete is a ground breaking material that can be encouraged in construction field.

1.1 Fibre-Reinforced Concrete

Fibre-reinforced concrete (FRC) is concrete in which fibrous material are added so that its structural integrity is increased. Short discrete fibres are added in uniform manner and randomly distributed.

Other fibres used are steel fibres, glass fibres, synthetic fibres and natural fibres – each of which lends different properties to the concrete. In addition, the properties of fibre-reinforced concrete changes with varying concretes, fibre materials, geometries, distribution, orientation, and densities.

1.1.1 Classification according to volume fraction

- **Low volume fraction**
  - The fibres are used to reduce shrinkage cracking.
  - Disperse fibres offer various advantages of to reduce shrinkage cracks :
    (a) The fibers are uniformly oriented in three-dimensions making an efficient load distribution;
    (b) The fibres are less susceptible to corrosion than the reinforcing steel bars,
    (c) The fibres can reduce the labour cost of placing the bars and wire mesh.
- **Moderate Volume Fraction**

The presence of fibres at this volume fraction increases the modulus of rupture, fracture toughness, and impact resistance. These composite are used in construction methods such as shotcrete and in structures that require energy absorption capability, spalling, and fatigue.

- **High Volume Fraction**

The fibres used at this level direct to strain hardening of the composites. Because of this improved behaviour, these composites are often known as high-performance fibre-reinforced composites (HPFRC). In the last decade, superior composites were developed and are referred as ultra-high-performance fibre reinforced concretes (UHPFRC).

1.1.2 Role of Fibre Size

- To bridge the large number of micro cracks in the composite under load and to avoid large strain localization it is necessary to have a large number of short fibres. The uniform distribution of short fibres increases the strength and ductility of the composite.
- Long fibres are needed to bridge discrete macro cracks at elevated loads; however the quantity of long fibres can be much smaller than the quantity of short fibres. The presence of long fibres significantly reduces the workability of the mix.

1.2 Studies On PET Bottles

Polyethylene Terephthalate (PET or PETE), or the obsolete PET-P or PETP, is a thermoplastic polymer resin of the polyester. If not properly disposed, PET leads to environmental damage and research on recycling of PET bottles has shown that the procedure can cause considerable environmental and economic problems. An effective procedure to reuse the waste PET bottles is by constructing reinforcing fibres from waste bottles and introducing them to cement-based composites to control plastic shrinkage cracking. Since the bottles are made of plastic material, they have many disadvantages and limitations. The low surface energy and characteristics of plastic materials results in a poor mechanical bonding with adjoining cement-based composite. This poor mechanical bonding may not provide enough bridging force in order to control crack development and can cause internal micro-cracks in the interfacial mechanical bonding area between a fibre and adjoining cement matrix. An effective way to enhance the mechanical bond strength of fibres having low surface energy is by altering the fibre geometry and surface. PET does not contain polyethylene so the term polyethylene Terephthalate remains as a source of confusion. The monomer ethylene Terephthalate is polymerized with repeating $C_{10}H_8O_4$ units to form PET. PET bottles are characterized by high strength, low weight, and low permeability of gases (mainly CO_2) as well as by their good light transmittance aesthetic appearance and smooth surface.

1.2.3 Application of PET Reinforced Concrete

1.2.3.1 Application To Mine Construction

As PET fibre had good mix ability and has satisfactory reinforcing quality, concrete (shotcrete) mixed with the PET fibre was installed at Hishikari Mine, Japan, operated by Sumitomo Metal Mining Co. Ltd. Hishikari Mine is a gold mine located in Kagoshima Prefecture, which is one of Japan's leading gold-producing areas. It was sprayed on a gateway which was not giving satisfactory result with steel reinforcement.

1.2.3.2. Pavement Of Narrow Areas

Passages in tunnels under construction, passages through underground structures, urban alleyways, and bush roads are mostly narrow, winding, and steeply. It is important to apply fibre-reinforced concrete to the pavement of such narrow sections of road; however, steel fibre if used can puncture tires, and conventional fibre has workability concerns. Thus, it has not been used previously to pave narrow sections of road in Japan. So, PET-fibre-reinforced concrete to pave bush roads was used keeping in mind its easy workability. PET-fibre-reinforced concrete was applied to a bush road between Hayatogawa and Kanazawa, Kanagawa Prefecture, Japan.

II. RESEARCH METHODOLOGY

The methodology followed in this research was determined by the objective of the study and the hypotheses statements listed in Chapter 1.

2.1 Experimental Approach

This chapter discusses the structured process for conducting the thesis. The quantitative method was used in data collection. The structured experiments and testing was conducted in the Soils and Concrete Laboratory at the Sree narayana Gurukulam College of engineering, Kadayiruppu and Ready Mix Concrete Private Limited , Edayar .

2.2 Mix Design

As per IS 10262:2009, the trial mixes for different ingredients proportion were performed and hence the design mix for M30 grade of concrete was prepared. The concrete mix proportions of 1: 1.49: 2.8 (1 part of cement , 1.49 parts of fine aggregate and 2.8 parts of coarse aggregate) with water cement ratio of 0.43. The plastic fibres were introduced into dry concrete mix in 0%, 0.5%, 1.0% and 1.5% by weight of cement. The different specimens were cast as per the requirements of test. After curing of 7 and 28 days these specimens were tested. There were three specimens tested in each category and the average value is reported. Percentage of super plasticizers varies from 0.5 to 0.7 % by weight of cement.

2.3 Materials

The materials used in this study included ordinary Portland cement, fine aggregate (manufactured sand), mixing water, super plasticizers and PET fibres (Straight and Crimped). The properties of these materials are presented in the following sections.

2.4 Cement

The cement used in all mixtures of the study was 53 grade Ordinary Portland cement, which conforming to IS 12269:2013. The physical and mechanical properties of the cement used are listed in Table 1. All the results meet the requirements of IS 12269:2013 specifications.

Table -1: Physical and mechanical properties of the cement used in the Study

Test	Results	Related Standards
Fineness	1%	IS 4031 (Part 2)
Standard consistency	36%	IS 4031
Initial setting time	80 min	IS 4031 (Part 5)

2.5 Fine Aggregate

The fine aggregate type used in the study was manufactured sand. M-Sand from metal quarry dust processing is the most suitable alternative to river sand. M-Sand is obtained by reduction of impurities from floating fine and uniform quarry dust granulation through pressurised water shower. The tests was carried out to find out the physical properties of fine aggregates and tabulated in Table 2. The tests that conducted are grain size analysis, specific gravity, bulk density, voids ratio and porosity of fine aggregates.

2.5.1 Grain size analysis of fine aggregate

The aim is to obtain the particle size distribution of M sand and also the effective size, fineness modulus, and uniformly coefficient according to IS 2386 – Part 1- 1963. Sieve sizes conforming to IS 460 – 1962 specifications, size, of sieves for fine aggregate (FA) 4.75mm, 2.36mm, 1.18mm, 600micron, 300micron, 150micron was considered.

Weight of fine aggregate = 1.5kg

Fig -1 : Grain size analysis of Fine Aggregates

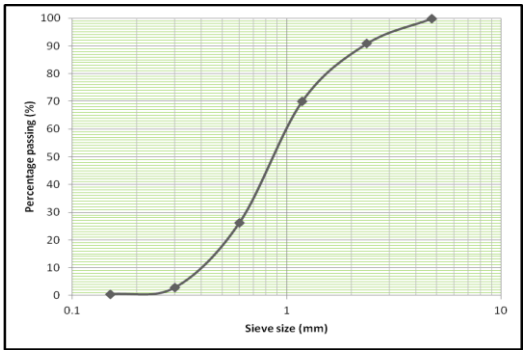


Fig -2 : Sieve size Vs Percentage passing

Table -2: Physical properties of Fine Aggregate.

Tests	Results
Fineness modulus	3.94
Specific gravity	2.88
Bulk density	1.402 kg/l
Void ratio	0.48

2.6 Coarse Aggregate

The coarse aggregate used in the study were 12.5 mm and 20 mm. The tests was carried out to find out the physical properties of fine aggregates and tabulated in Table 3. The tests that conducted are grain size analysis, specific gravity, bulk density, voids ratio and porosity of coarse aggregates.

2.6.1 Grain size analysis of coarse aggregate

The aim is to obtain the particle size distribution of coarse aggregate and also the effective size, fineness modulus, and uniformly coefficient according to IS 383 (PART III) - 1970. Sieve sizes conforming to IS 460 – 1962 specifications, size, of sieves for coarse aggregate (CA) 40 mm, 20 mm, 12.5 mm, 10 mm, 4.75 mm was considered.

Weight of fine aggregate = 3 kg

Fig -3: Grain size analysis of Coarse Aggregates

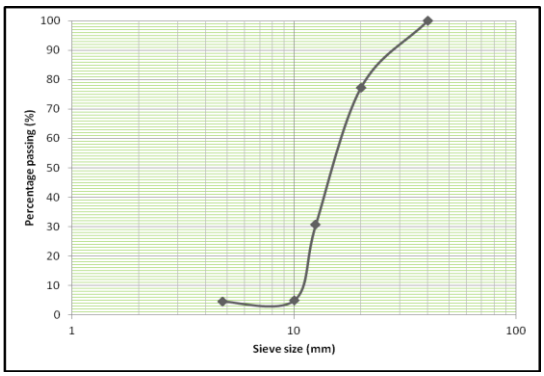


Fig -4: Sieve size Vs Percentage passing

Table -3: Physical properties of Coarse Aggregate.

Tests	Results
Fineness modulus	3.788
Specific gravity	2.84
Bulk density	1.6 kg/l
Void ratio	0.811

2.7 Mixing Water

For mixing and curing of specimens throughout the experimentation potable water was used. It is drinkable, clear and apparently clean, and does not contain any substances at excessive amounts that can be harmful for making concrete.

2.8 Chemical Admixture

Parameters	Straight PET Fibre	Crimped PET Fibre
Absorption	Nil	Nil
Fibre length	15 , 30 , 45 mm	15 , 30 , 45 mm
Aspect	Straight	Crimped
Mechanical bond strength	1.7 MPa	3.9 MPa
Thermal conductivity	Low	Low
Acid and salt resistance	High	High
Specific gravity	1.34	1.34
Electrical conductivity	Low	Low
Alkali resistance	Alkali proof	Alkali proof

To impart additional workability a super plasticizer CONPLAST SP 430 was used. The super plasticizer was added 0.5 to 0.7 % by weight of cement to all mixes.

2.9 Poly Ethylene Terephthalate Fibres

The PET mineral water bottles from two brands which are post consumed were collected from waste dwellers. After removing the neck part and bottom part of the bottle the fibres were cut-out. The length of fibres was kept 15 mm, 30 mm, 45 mm and the breadth was maintained 2 mm throughout. The aspect ratio (AR) of waste plastic fibres were 8 (AR 8), 15 (AR 15) and 23 (AR 23). The plastic fibres used were having water absorption 0 %, specific gravity 1.34. The different fractions for three aspect ratios were used in this experimentation. Fig. 6 and 7 shows the PET fibres.The PET fiber types adopted for the experimental program were **Straight and Crimped PET fibre**.

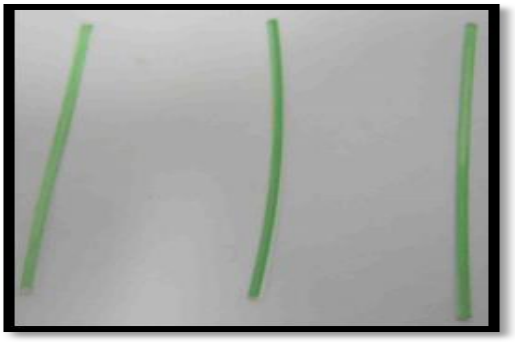


Fig -5: Straight Fibres

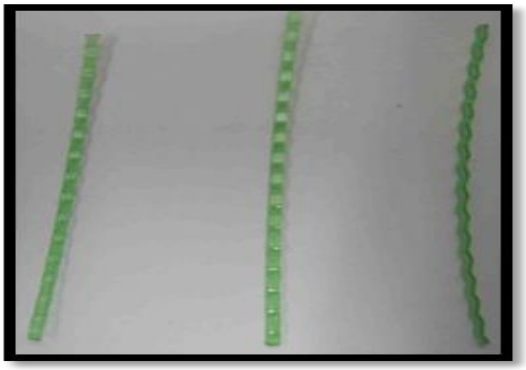


Fig -6: Crimped Fibres

2.9.1 Advantages of PET Fibres

- The Poly Ethylene Terephthalate fibres are chemically inert
- PET Fibers do not corrode
- PET Fibers are lighter than steel fibres of the same number
- They allow a better control of the plastic shrinkage cracking

2.9.2 Chemical and physical properties

Table -4: Chemical and physical properties of PET fibres

2.10 Machine Mixing

Mixing was done using a concrete machine mixer. The raw materials were combined and mixed to an even colour prior to adding water. Water was then slowly added with the continuous turning of the mix until slurry having required workability is obtained. It is important that slurry is used within an hour of mixing and should not re-temper by the addition of water. With regards to the curing of specimen, the specimens remained in curing tank for 28 days.

Fig -7 : Concrete Mixing

Fig -8 : Preparation of Specimens

2.11 Experimental Program

2.11.1 Properties of Fresh Concrete

The most important property of concrete in fresh state is workability. It is defined as the ease with which concrete can be mixed, transported, placed and finished easily without segregation. Workability of fresh concrete is obtained by conducting slump cone test for each percentage of plastic fibres at all batches of concrete and the average value obtained is reported.

Fig -9 : Slump Test

III. RESULTS AND OBSERVATIONS

3.1 Results

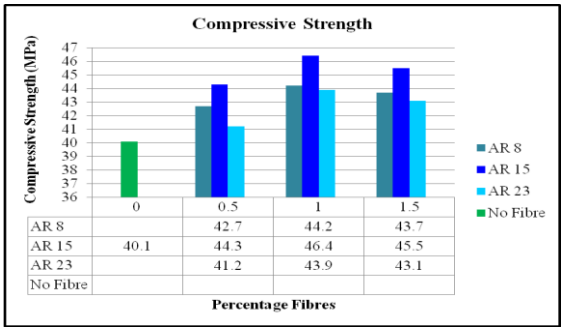
A total of 171 specimens were cast, 81 specimens with Straight PET fibres, 81 for Crimped PET fibres and remaining 9 specimens without adding fibres . Testing was carries out after 28^{th} days of curing.

3.2 Slump Cone Test

The workability of fresh concrete was measured in terms of slump. Workability has a broad range from very low (at slump 0 to 25 mm) applied for vibrated concrete in roads or other large sections, to high workability (slump 100 to 180 mm). It can be observed from the values of slump that the workability decreases with the increase in percentage of fibre for both straight and crimped PET fibres. For 0% fibres the maximum slump obtained for M30 grade of concrete was observed to be 120 mm. It was also noted that there is decrease in the slump value as the length of the fibre increases.

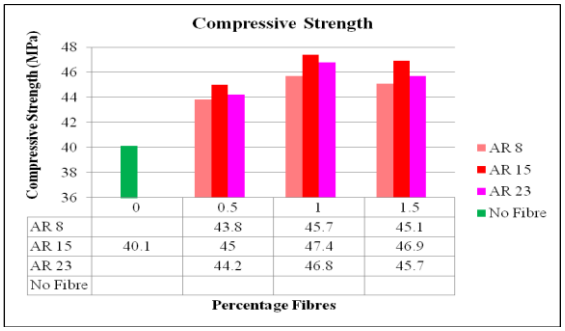
3.3 Compression Test

Compression test is the most common test conducted on hardened concrete, partly because it is an easy test to perform, and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. For the experiment, cube size of 15 x 15 x 15 cm was adopted. After 28th days of curing, the specimens were taken out and allow it for dry. Then the specimens were subjected to compression on compression testing machine. The compressive test results of the cube specimen with Straight and Crimped fibres are as follows,



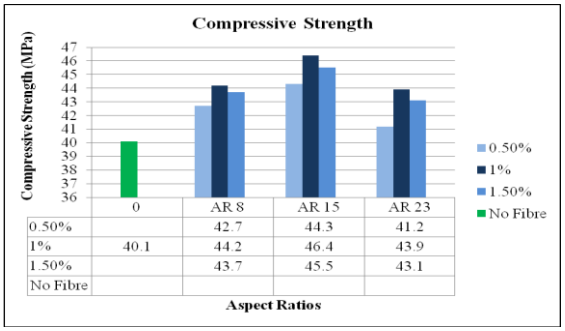
	0	0.5	1	1.5
AR 8		42.7	44.2	43.7
AR 15	40.1	44.3	46.4	45.5
AR 23		41.2	43.9	43.1
No Fibre				

Fig -10 : 28 th day compressive strength result of cube specimens with Straight PET fibres for different aspect ratios



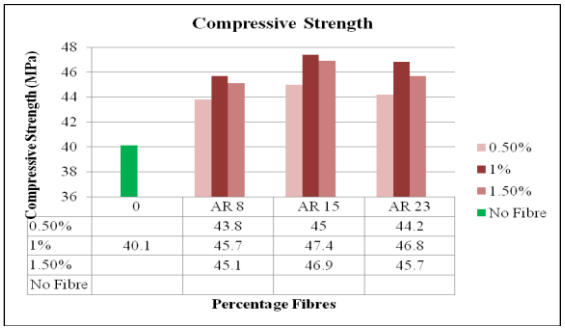
	0	0.5	1	1.5
AR 8		43.8	45.7	45.1
AR 15	40.1	45	47.4	46.9
AR 23		44.2	46.8	45.7
No Fibre				

Fig -11 : 28 th day compressive strength result of cube specimens with Crimped PET fibres for different aspect ratios



	0	AR 8	AR 15	AR 23
0.50%		42.7	44.3	41.2
1%	40.1	44.2	46.4	43.9
1.50%		43.7	45.5	43.1
No Fibre				

Fig -12 : 28 th day compressive strength result of cube specimens with Straight PET fibres for different fibre percentages



	0	AR 8	AR 15	AR 23
0.50%		43.8	45	44.2
1%	40.1	45.7	47.4	46.8
1.50%		45.1	46.9	45.7
No Fibre				

Fig -13 : 28 th day compressive strength result of cube specimens with Crimped PET fibres for different fibre percentages

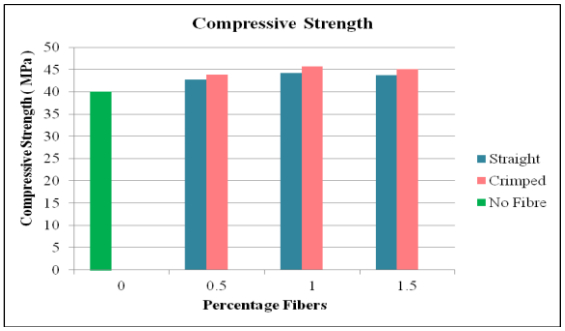


Fig.14 : 28 th day compressive strength result of cube specimens with AR-8 Straight and Crimped PET fibres

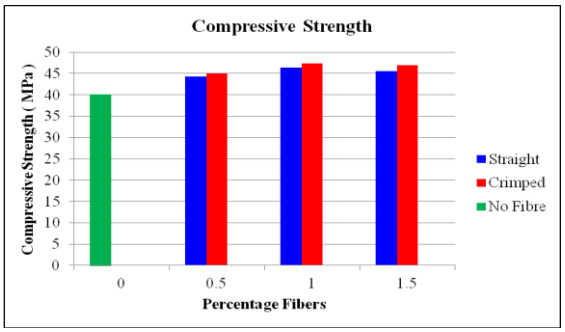


Fig -14 : 28 th day compressive strength result of cube specimens with AR-15 Straight and Crimped PET fibres

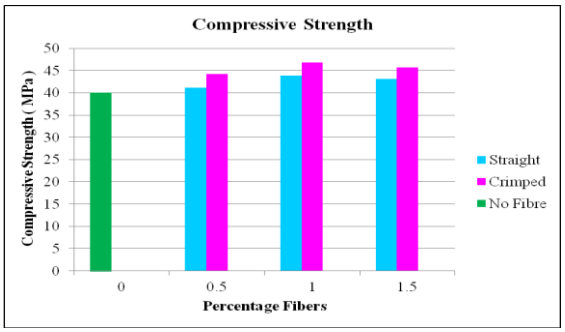


Fig -15 : 28 th day compressive strength result of cube specimens with AR-23 Straight and Crimped PET fibres

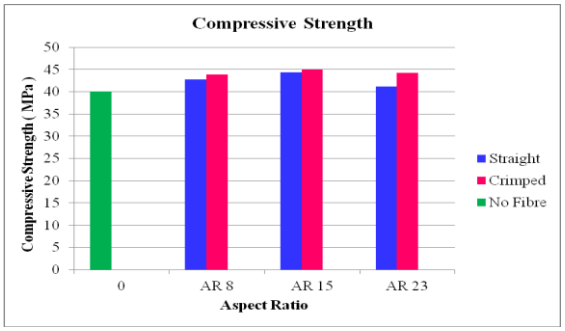


Fig -15 : 28 th day compressive strength result of cube specimens with 0.5% Straight and Crimped PET fibres

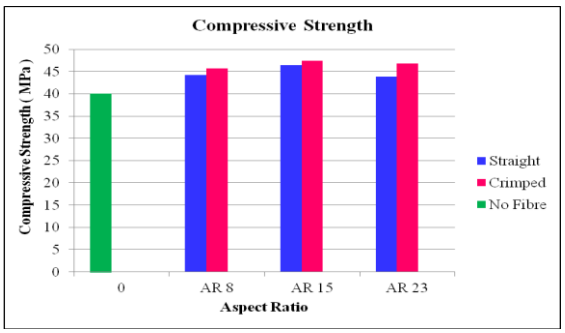


Fig -16 : 28 th day compressive strength result of cube specimens with 1% Straight and Crimped PET fibres

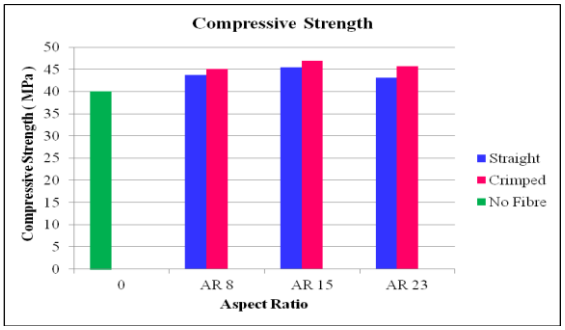


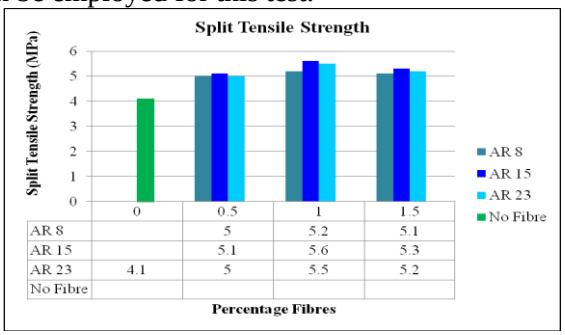
Fig -17 : 28 th day compressive strength result of cube specimens with 1.5% Straight and Crimped PET fibres

Fig -18 : Compression test specimens without and with fibres after testing

3.4 Split Tensile Test

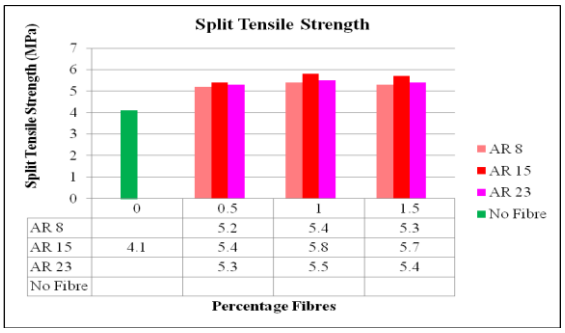
The splitting test is well known indirect tests used for determining the tensile strength. The test consists of applying compressive line loads along the opposite generators of a cylinder specimen placed with its axis horizontal between the platens. The tensile test subjects the specimen to a uniaxial

tension until it fails. The compression testing machine was used for the splitting tensile test. The main advantage of this method is that the same type of specimen and the same testing machine as are used for the compression test can be employed for this test.



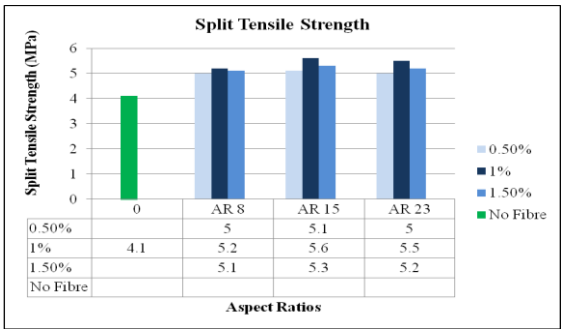
	0	0.5	1	1.5
AR 8		5	5.2	5.1
AR 15		5.1	5.6	5.3
AR 23	4.1	5	5.5	5.2
No Fibre				

Fig -19 : 28 th day Split Tensile strength result of cylinder specimens with Straight PET fibres for different aspect ratios



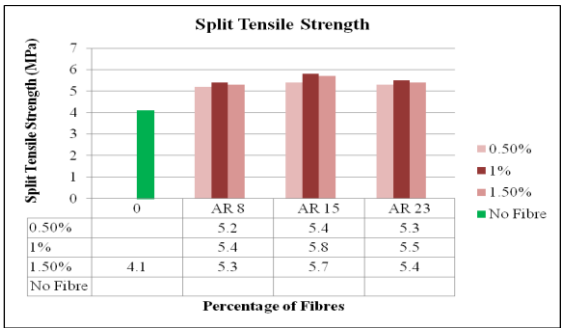
	0	0.5	1	1.5
AR 8		5.2	5.4	5.3
AR 15	4.1	5.4	5.8	5.7
AR 23		5.3	5.5	5.4
No Fibre				

Fig -20 : 28 th day Split Tensile strength result of cylinder specimen with Crimped PET fibres for different aspect ratios



	0	AR 8	AR 15	AR 23
0.50%		5	5.1	5
1%	4.1	5.2	5.6	5.5
1.50%		5.1	5.3	5.2
No Fibre				

Fig -21 : 28 th day Split Tensile strength result of cylinder specimens with Straight PET fibres for different fibre percentages



	0	AR 8	AR 15	AR 23
0.50%		5.2	5.4	5.3
1%		5.4	5.8	5.5
1.50%	4.1	5.3	5.7	5.4
No Fibre				

Fig -22 : 28 th day Split Tensile strength result of cylinder specimen with Crimped PET fibres for different fibre percentages

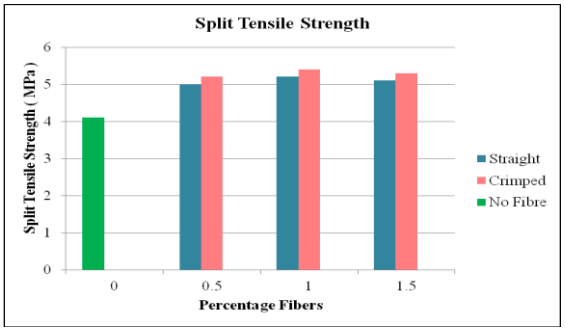


Fig -23 : 28 th day Split Tensile Strength result of cylinder specimens with AR-8 Straight and Crimped PET Fibres

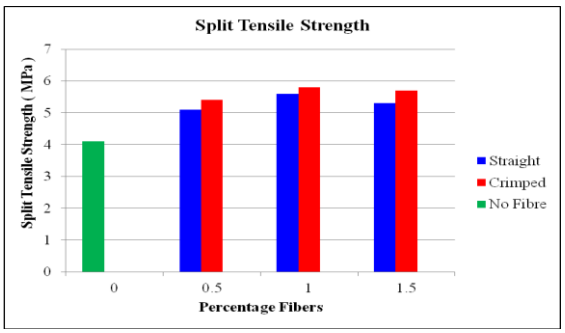


Fig -24 : 28 th day Split Tensile Strength result of cylinder specimens with AR-15 Straight and Crimped PET Fibres

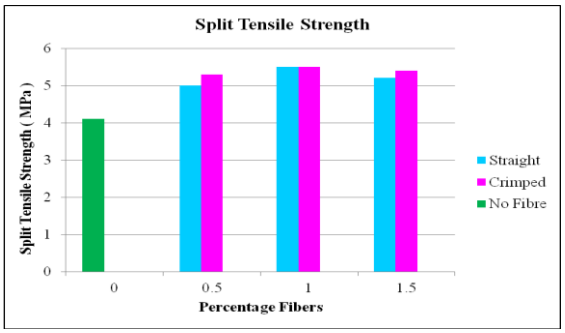


Fig -25 : 28 th day Split Tensile Strength result of cylinder specimens with AR-23 Straight and Crimped PET Fibres

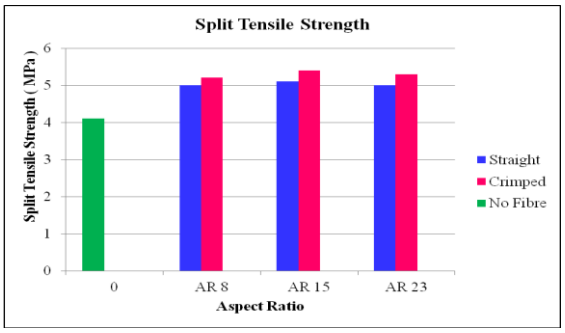


Fig -26 : 28 th day Split Tensile Strength result of cylinder specimens with 0.5 % Straight and Crimped PET Fibres

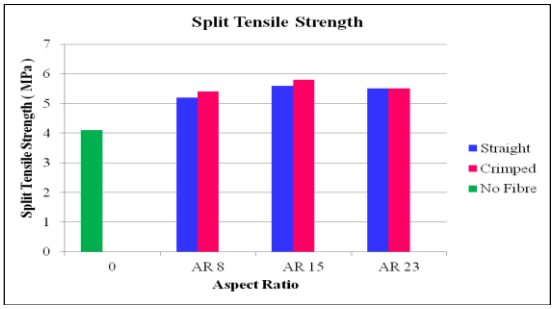


Fig -27 : 28 th day Split Tensile Strength result of cylinder specimens with 1 % Straight and Crimped PET Fibres

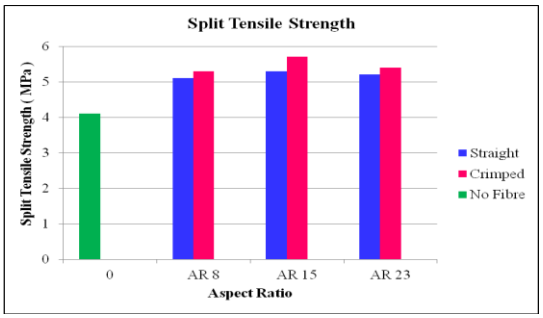


Fig -28 : 28 th day Split Tensile Strength result of cylinder specimens with 1.5 % Straight and Crimped PET Fibres

Fig -29 : Split Tensile Test specimens with and without fibres after testing

3.5 Flexural Strength Test

The flexural tensile strength test is performed to estimate the tensile load, at which the concrete cracks. This is an indirect test for assessing the tensile strength at failure or modulus of rupture. The test was carried out on beam having 10 x 10 x 50 cm size and the load was applied continuously until it fails. The flexure strength test results of the specimens with Straight and Crimped fibres are noted and tabulated as follows,

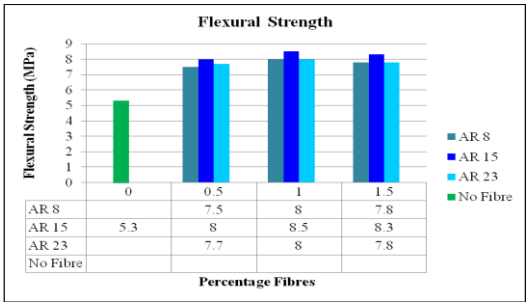
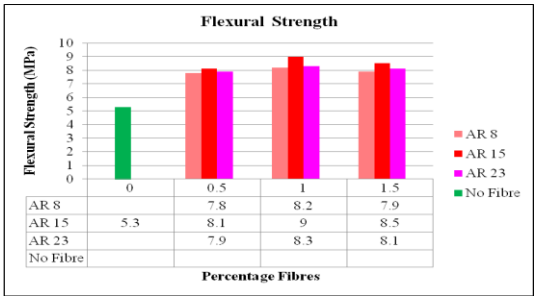
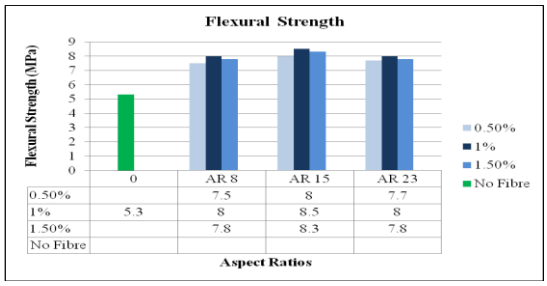


Fig -30 : 28 th day Flexural Strength result of beam specimens with Straight PET fibres for different aspect ratios



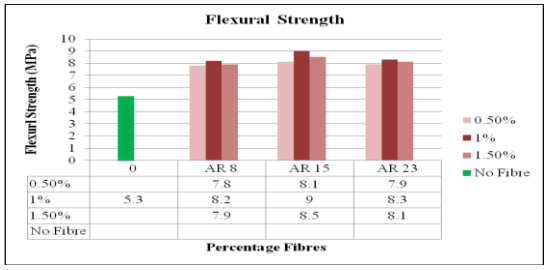
	0	0.5	1	1.5
AR 8		7.8	8.2	7.9
AR 15	5.3	8.1	9	8.5
AR 23		7.9	8.3	8.1
No Fibre				

Fig -31 : 28 th day Flexural Strength result of beam specimens with Crimped PET fibres for different aspect ratios



	0	AR 8	AR 15	AR 23
0.50%		7.5	8	7.7
1%	5.3	8	8.5	8
1.50%		7.8	8.3	7.8
No Fibre				

Fig -32 : 28 th day Flexural Strength result of beam specimens with Straight PET fibres for different fibre percentages



	0	AR 8	AR 15	AR 23
0.50%		7.8	8.1	7.9
1%	5.3	8.2	9	8.3
1.50%		7.9	8.5	8.1
No Fibre				

Fig -33 : 28 th day Flexural Strength result of beam specimen with Crimped PET fibres for different fibre percentages

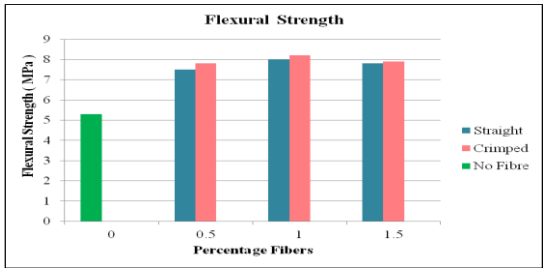


Fig -34 : 28 th day Flexural Strength result of beam specimens with AR-8 Straight and Crimped PET Fibres

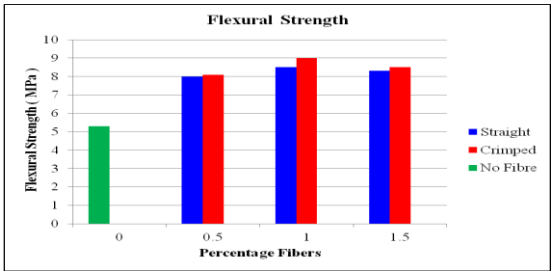


Fig -35 : 28 th day Flexural Strength result of beam specimens with AR-15 Straight and Crimped PET Fibres

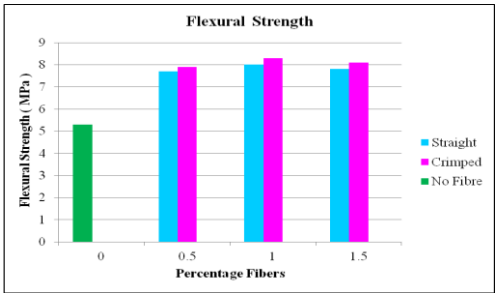


Fig -36 : 28 th day Flexural Strength result of beam specimens with AR-23 Straight and Crimped PET Fibres

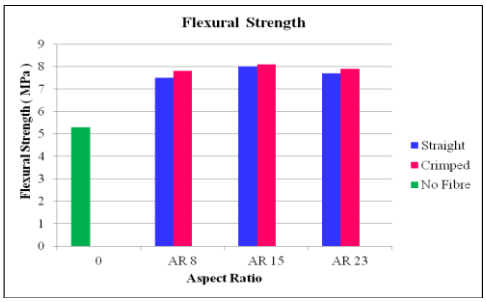


Fig -37 : 28 th day Flexural Strength result of beam specimens with 0.5 % Straight and Crimped PET Fibres

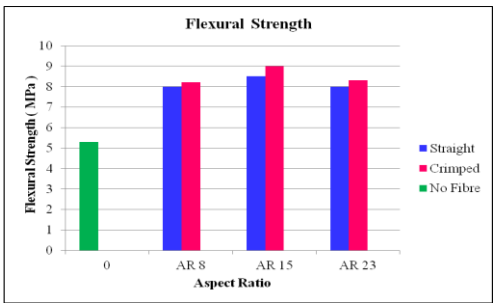


Fig -38 : 28 th day Flexural Strength result of beam specimens with 1 % Straight and Crimped PET Fibres

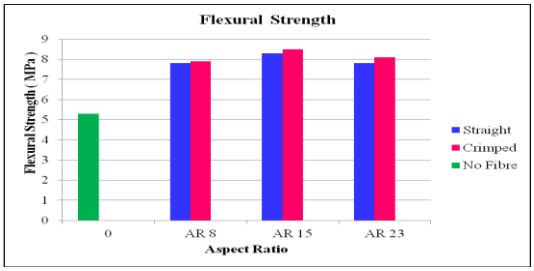


Fig -39 : 28 th day Flexural Strength result of beam specimens with 1.5 % Straight and Crimped PET Fibres

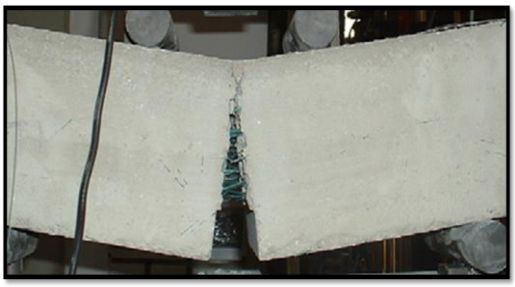


Fig -40 : Flexural Test specimens with fibres after testing

IV. CONCLUSIONS

From the experimental results the foremost conclusions were derived as follows.
Addition of fibres content affects flow properties of concrete. This study examined how workability and strength parameters depend on fibre geometry and fraction by volume to investigate the use of post consumed waste PET bottles as reinforcing fibres to improve strength parameters in cement-based composites. From this slump test it was obtained that workability of plain PET-fibre reinforced concrete was decreased with the increase in percentage of fibre volume fraction and this may be due to the resistance offered by the fibres against the movement of aggregates. Proper attention need to be paid to the mix design to have same workability as plain concrete with the same w/c ratio.
The major improvements in strengths were observed with addition of plastic fibres in concrete. The optimum strength was obtained at 1% of fibre content for all type of strengths there after declinations in strength were observed. It can be observed from the test results that for aspect ratio 15, strength development was higher. The tensile strength and flexural strength at relatively low fibre content (up to 1%) are affected by fibre geometry, i.e., the mechanical bond strength. Therefore, the crimped type fibre, which had superior mechanical bond strength, conferred the best resistance to strength parameters.
The maximum percentage increase in compressive strength at 1% of fibre content were 16 % and 18 % for straight and crimped PET fibre for aspect ratio 15 respectively over control concrete (0% fibres). Spalling of concrete was observed while the tests were conducted in the control cement concrete cube. However, the failure mode of fibre concrete was bulging in transverse direction. From the test results it is observed that the tensile strength was increased with increase in fibres with the concrete. For maximum 1 % volume fractions of PET-fibres, tensile strength increased by 37 % and 42 % compared to the plain concrete reference cylinders for straight and crimped PET fibres. Moreover, the control batch specimens containing no fibres failed suddenly once the concrete cracked, while the PET- fibre reinforced concrete specimens still remained as unique.The addition of straight and crimped PET-fibres to concrete improved the shear capacity. Shear capacity of concrete beam increased by 60 % and 70% due to addition of Straight and Crimped PET-fibres respectively, compared to the plain concrete specimen. These results indicate the fact that macro synthetic fibre reinforcement enhanced the shear capacity although the 1 % fibre volume fraction is seems to be optimal. The reduction beyond this percentage may be due to the weak bonding of fibre to concrete matrix.
It was found that normal concrete specimens failed suddenly into two pieces at ultimate strength whereas PET fibre specimens did not fail suddenly. A change in nature of failure occur from brittle to ductile when plastic fibres were introduced into the concrete. From this experimental investigation, it can be concluded that the PET bottles appear to be a low-cost material which would help to solve the solid waste problems and preventing environmental pollution.

REFERENCES

[1]. T. Ochi, S. Okubo, K. Fukui (2007), "Development of recycled PET fibre and its application as concrete reinforcing fibre", *Cement and Concrete Composites 29*, 448-455
[2]. P. Ganesh prabhu, C. Arun kumar, R. Pandiyaraj, P. Rajesh & L. Sasi kumar (2014) "Study on Utilization of waste PET bottle fibre in concrete", *International Journal of Research in Engineering & Technology* Vol. 2, Issue 5, May 2014

[3]. Mahzabin Afroz, M. Jobaer Hasan, Md. Mahmudul Hasan (2013), "Performance of plain PET fibres to enhance the mechanical behavior of concrete under tension and shear" *International Journal of Science, Engineering and Technology Research , Volume 2, Issue 9, September 2013*

[4]. R. N. Nibudey, P. B. Nagarnaik, D. K. Parbat & A. M. Pande , (2013), "Strength And Fracture Properties of Post Consumed Waste Plastic Fiber Reinforced Concrete", *International Journal of Civil, Structural, Environmental and InfrastructureEngineering Research and Development (IJCSEIERD)* Vol. 3, Issue 2, Jun 2013, 9-16

[5]. K. Ramadevi, R. Manju (2012), "Experimental investigation on the properties of concrete with Plastic PET (bottle) fibres as fine aggregates", *International Journal of Emerging Technology and Advanced Engineering* Volume 2 Issue 6, 42-46

[6]. G. Murali, C. M. VivekVardhan, R. Prabu, Z. MohammedSadaquath Ali Khan, T. Aarif Mohamed and T. Suresh (2012) "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.

[7]. Fernando Fraternali, Vincenzo Ciancia, Rosaria Chechile, Gianvittorio Rizzano, Liciano Feo, Loredana Incarnato (2011), "Experimental study of the thermo-mechanical properties of recycled PET fibre-reinforced concrete", *Composit Structures* 93, 2368-2374

[8]. Prahallada M. C, Prakash K.B, "Effect of replacement of Cement by Microsilica - 600 on the properties of Waste Plastic Fibre Reinforced (WPFRC) Concrete - An experimental investigation" , *International Journal Of Civil And Structural Engineering Volume 2, No 1, 2011*

[9]. Venu Malagavelli, Rao P.N. (2010), "Effect of non bio degradable waste in concrete slabs", *International Journal of Civil and Structural Engineering* Volume 1 No 3 , 449-457

[10]. Rafat Siddique, Jamal Khatib, Inderpreet Kaur (2008), "Use of recycled plastic in concrete: A review", *Waste Management 28*, 1835-1852

[11]. Byung-Wan Jo, Ghi-Ho Tae, Chang-Hyun Kim (2007) , "Uniaxial creep behavior and prediction of recycled-PET polymer concrete" , *Construction and Building Materials.*

[12]. Kim JJ, Park CG, Lee SiW, Lee SaW, Won JP. "Effects of the geometry of recycled PET fibre reinforcement on shrinkage cracking of cement- based composites." Composites Part B: Eng 2007; 39:442–50.

[13]. Silva D. A., Betioli A. M., Gleize P. J. P., Roman Gomez L. A., Riberio J. L.D., (2005), "Degradation recycled PET fibres in Portland cement-based materials" *Cement and Concrete Research*, 35: 1741-1746.