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An Experimental Study On The Properties Of Pet Fibre Reinforced Concrete

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ABSTRACT

Utilization of waste material in concrete would be beneficial in order to find an alternative solution to reduce environmental pollution. One of the waste materials is polyethylene terephthalate (PET) which is a polyester material and is produced in large quantities. In this work fibres are simply cut from waste plastic bottles reducing, in this way, the manufacturing costs of recycled PET fibre concrete. In India approximately 40 million tons of solid waste is produced, annually. This is increasing at a rate of 1.5 to 2% every year. Plastics constitute 12.3% of total waste produced most of which is from discarded water bottles. One possible solution is using RPET as short fibres in concrete. It can provide greater crack control and ductility enhancement capacities for quasi-brittle concrete as well as mass consumption alternative, which is a very important issue in the merit of recycling waste materials. The aim of this work is to explore the possibility of a waste material to be used in concrete as fibre. The dimensions of PET fibres used are 30 mm long, 5mm width and 0.6mm thickness in the various percentages 0%, 2%, 4%, and 6% of fibre in total weight of concrete. In this study cubes, cylinders, beams specimens are proposed to be carried out and their compressive strength, split tensile strength, flexural strengths will be compared. Then optimum percentage of PET fibre is found out.
Keywords: Experimental Study, Properties, Pet Fibre, Reinforced Concrete

1.INTRODUCTION

1.1General

Polyethylene terephthalate (PET) is one of the most important synthetic fibres for industrial production. Concrete reinforced with PET fibres from used PET bottles can be easily made as PET bottles are commonly used these days. Concrete is strong in compression but weak in tension. To eliminate this problem, the introduction of fibres was brought in as an alternative to developing concrete in view of enhancing its tensile strength as well as improving its ductile property. The largest use of PET currently is in containers. In this area, beverage and mineral water bottles are standing in prime position. The current worldwide production of PET exceeds 6.7 million tons/year. In India, domestic waste plastics are causing considerable damage to the environment and hence an attempt has been made to understand whether they can be successfully used in concrete to improve some of the mechanical properties. Among different waste fractions, plastic waste deserves special attention on account non-biodegradable property which is creating a lot of problems in the environment. In India approximately 40 million tons of solid waste is produced annually. This is increasing at a rate of 1.5 to 2% every year. Plastics constitute 12.3% of total waste produced most of which is from discarded water bottles. The PET bottles cannot be disposed of by dumping or burning, as they produce uncontrolled fire or contaminate the soil and vegetation. One possible solution is using RPET as reinforcing short fibres in structural concrete. It can provide greater crack control and ductility enhancement capacities for quasi-brittle concrete as well as mass consumption alternative, which is a very important issue in the merit of recycling wasted materials. The main application of PET fibres is to reduce the environmental pollution due to plastic wastes.

1.2 Fibre Reinforced Concrete

Reinforced Concrete is a concrete mix that contains short, discrete fibres that are uniformly distributed and randomly oriented. Fibres used are steel fibres, synthetic fibres, glass fibres, and natural fibres. The main function of the fibres in members is that of resisting the opening of the cracks due to micro cracking, increasing the ability of the member to withstand loads. The characteristic of fibre reinforced concrete are changed by the alteration of quantities of concrete, fibre substances, geometric configuration, dispersal, direction and concentration. It is a special type of concrete in which cement based matrix is reinforced with ordered or random distribution of fibre.

1.3 Structural Performance Of FRC

- It improves the impact resistance and shear strength.
- It increases crack resistance and toughness.
- It increases load carrying capacity and provides uniform multi-directional reinforcement in concrete.
- Fibres prevent micro cracks from widening.
- It provides better energy absorption.
- Fibre prevents sudden and catastrophic failures under earth quake and blast type loading.

1.4 Role Of Fibres In Concrete

Fibres are available in different sizes and shapes. They can be classifieds into two basic categories, namely those having a higher elastic modulus than concrete matrix and those with lower elastic modulus. Steel, glass and carbon have high elastic module than cement mortar, and polypropylene and vegetables fibres are the low modulus fibres. High modulus fibres improve both flexural and impact resistance simultaneously and low modulus fibres improve the impact resistance of concrete but do not contribute much too flexural strength. In contrast to reinforcing bars in concrete which are continuous and carefully placed in the structure to optimize their performance, the fibres are discontinuous and are randomly distributed throughout the concrete matrix. Essentially fibres act as crack arrestor restricting the development of cracks and thus transforming an inherently brittle matrix into a strong composite with superior crack resistance, improved ductility and distinctive post-cracking behaviour prior to failure.

1.5 Effects Of Fibres In Concrete

Fibres are generally used in concrete to control cracking due to both plastic shrinkage and drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibres produce greater impact, abrasion and shatter resistance in concrete. The aspect ratio of the fibre (l/d) is calculated as the ratio of length to diameter (d). If the modulus of elasticity of the fibre is higher than the matrix, they help to carry the load by increasing the tensile strength of the material. Increase in the aspect ratio of the fibre usually augments the flexural strength and toughness of the matrix.

1.6 Objectives

This investigation is to be reduce environmental pollution by the use of PET bottles in concrete. Study the flexural behavior of concrete contains PET fibres and to check the compatability of PET fibre in concrete. The investigation is also aimed to find out the optimum percentage of PET fibre in concrete.

2. METHODOLOGY

Figure.1 shows the methodology adopted in this study

Figure.1 Methodology

3.THEORETICAL STUDY

3.1 Introduction

The materials used in the concrete were cement, fine and coarse aggregate, PET fibre. This experimental study is to investigate the physical and chemical properties of various materials.

3.2 Cement

The cement used should confirm to IS specifications. There are several types of cements are available commercially in the market of which Portland Pozzolana cement is the most known and available everywhere. PPC super grade was used for this study.

3.3 Fine Aggregate

Fine aggregate / sand is an accumulation of grains of mineral matter derived from the disintegration of rocks. It is distinguished from gravel only by the size of the grains or particles, but is distinct from clays which contain organic materials. Sands that have been sorted out and separated from the organic material by the action of currents of water or by winds across arid lands are generally quite uniform in size of grains. Usually commercial sand is obtained from river beds or from sand dunes originally formed by the action of winds. Much of the earth's surface is sandy, and these sands are usually quartz and other siliceous materials. The most useful commercially are silica sands, often above 98% pure. Beach sands usually have smooth, spherical to ovaloid particles from the abrasive action of waves and tides and are free of organic matter. The white beach sands are largely silica but may also be of zircon, monazite, garnet, and other minerals, and are used for extracting various elements. Sand is used for making mortar and concrete and for polishing and sandblasting. Sands containing a little clay are used for making moulds in foundries. Clear sands are employed for filtering water. Sand is sold by the cubic yard (0.76 m3) or ton (0.91 metric ton) but is always shipped by weight. The weight varies from 1,538 to 1,842 kg/m3, depending on the composition and size of grain. Construction sand is not shipped great distances, and the quality of sands used for this purpose varies according to local supply. Standard sand is a silica sand used in making concrete and cement tests. The fine aggregate obtained from river bed of Kavery, clear from all sorts of organic impurities was used in this experimental program. The fine aggregate was passing through 4.75 mm sieve and had a specific gravity of 2.66. The grading zone of fine aggregate was zone II as per Indian Standard specifications.

3.4 Coarse Aggregate

Coarse aggregate are the crushed stone is used for making concrete. The commercial stone is quarried, crushed, and graded. Much of the crushed stone used is granite, limestone, and trap rock. The last is a term used to designate basalt, gabbro, diorite, and other dark- coloured, fine-grained igneous rocks. Graded crushed stone usually consists of only one kind of rock and is broken with sharp edges. The sizes are from 2 to 2.5 in (0.64 to 6.35 cm), although larger sizes may be used for massive concrete aggregate. Machine crushed granite broken stone angular in shape was used as coarse aggregate. The maximum size of coarse aggregate was 20 mm and specific gravity of 2.71. Granite is a coarse-grained, igneous rock having an even texture and consisting largely of quartz and feldspar with often small amounts of mica and other minerals. There are many varieties. Granite is very hard and compact, and it takes a fine polish, showing the beauty of the crystals. Granite is the most important building stone. Granite is extremely durable, and since it does not absorb moisture, as limestone and sandstone do, it does not weather or crack as these stones do. The colours are usually reddish, greenish, or gray. Rainbow granite may have a black or dark- green background with pink, yellowish, and reddish mottling; or it may have a pink or lavender background with dark mottling. The density is 2,723 kg/m3, the specific gravity 2.71, and the crushing strength 158 to 220 MPa.

3.5 Water

The quality of mixing water for concrete has a visual effect on the resulting hardened concrete. Impurities in water may interfere with setting of cement and will adversely affect the strength and durability of concrete with steel slag. Fresh and clean water which is free from organic matter, silt, oil, and acid material as per standards is used for casting and curing the specimens. Usually water that is piped from the public supplies is regarded as satisfactory.

3.6 Pet Fibre

PET fibres are made from the waste bottles. They are cut into the dimensions of 30mm x 5mm size to use in the concrete.PET fibres prepared by the directly cutting PET bottle into required size. We get the sources from Pallava Textile Limited, Erode India. For the last 2 decades They are one of the leading manufacturers and exporters of variety of high quality textile yarns like viscose yarn, vortex yarn, micromodal yarn, tencel yarn, bamboo yarn, cotton modal blended yarn, core spun yarn, PC blends etc.(Figure.2)

Figure 2 PET Fibre

4.EXPERIMENTAL RESULT

4.1 Fresh Concrete

Though fresh state is transient, its condition seriously affects the behavioral properties of the final product. Poor compaction and improper curing will lead to porous concrete with low strength and high permeability. Fresh concrete is freshly mixed material which can be moulded into any shape. The relative quantities of cement, aggregate and water mixed together control the properties of concrete in wet state as well as in hardened state.

Workability

Workability is defined as the ease to placement with resistance to segregation. According to ACI:116R-90 workability is defined as the property of freshly mixed concrete or mortar which determines the case and homogeneity with which it can be mixed, placed, consolidated and finished. According to ASTM: C125 workability is the property of determining the effort required to manipulate a fresh mixed quantity of concrete with minimum loss of homogeneity. Therefore, the workability of concrete is associated with terms such as flow ability, mobility, stability, resistance to segregation, and palpability. Workability is necessary to compact concrete to the maximum possible density.

4.1.1 Slump Test

Slump is a measure indicating the consistency or workability of cement concrete. It gives an idea of water content needed for concrete to be used for different works. A concrete is said to be workable if it can be easily mixed and placed, compacted and finished. A workable concrete should not show any segregation or bleeding. Segregation is said to occur when coarse aggregate try to separate out from the finer material and a concentration of coarse aggregate at one place occurs. This results in large voids, less durability and strength. Bleeding of concrete is said to occur when excess of water comes up at the surface of concrete. This causes small pores through the mass of concrete and is undesirable.

4.1.2 Compaction Factor Test

It gives an idea of degree of compaction and can be defined as the ratio of the density actually achieved in the test to the density of fully compacted concrete. The degree of compaction in this test is high. The degree of compaction in this test is achieved by allowing the concrete to fall from standard height to the container. This test is more sensitive and precise when compared to slump test and particularly useful for concrete mixes of very low workability as are normally used when concrete are insensitive to slump flow. This test works on the principle of determining the degree of compaction achieved by the standard amount of work done by allowing the concrete to fall through a certain height. Compaction factor test is adopted to determine the workability of concrete, where the nominal maximum size of aggregate does not exceed 40mm and is primarily used in laboratory. The compaction factor test is able to indicate small variation in the workability over a wide range. The compaction factor test has been developed at the road research laboratory U.K. and is claimed that it is one of the most efficient test for measuring the workability of concrete.

4.2 Hardened Concrete

4.2.1 Compressive Strength Test

The experimental work involves casting of concrete cubes of size 150mm X 150mm X 150mm for determination of compressive strength for 7 days 14 days and 28 days. Cubes were casted for conventional concrete. The Compressive strength is calculated by load by area Unit N/mm2.

Testing of Concrete Cubes

For cube compression tests on concrete, cube of size 150mm were employed. All the cubes were tested in saturated condition after wiping out the surface moisture from the specimen. For each trial mix combination, three cubes were tested at the age of 7, 14 and 28 days of currying using 400 tone cubes were tested at the age of

7,14 and 28 days of currying using 400 tone compression testing machine. The tests were carried out at a uniform stress after the specimen has been centered in the testing machine. Loading was continued till the dial gauge needle just reserves its direction of motion. The reversal in the directions of motion of the needle indicates that the specimen has failed. The dial reading at the instant was noted, which is the ultimate load. The ultimate load divided by the cross section area of the specimen is equal to the ultimate cube compressive strength. Compressive strength = load / area (N/mm^2) (Table.1)

Table 1 Compressive Strength (N/mm^2) of concrete

DAYS	SAMPLE	AREA (mm^2)	LOAD (kN)	COMPRESSIVE STRENGTH (N/mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)
7	1	22500	490	21.78	22.89
	2	22500	525	23.33	
	3	22500	530	23.56	
14	1	22500	550	24.44	24.81
	2	22500	560	24.89	
	3	22500	565	25.11	
28	1	22500	600	26.67	27.85
	2	22500	630	28.00	
	3	22500	650	28.89	

4.2.2 Split Tensile Strength Test

This tests are carried out in accordance with IS 516-1999 standards conducted on concrete cylinders of 150 mm diameter and 300 mm length. Split tensile strength for 7 days ,14 days and 28 days. Cylinders were casted conventional concrete. The splitting tensile strength has been calculated using the formula(Table.2)

$$\text{Split tensile strength} = \frac{2 * P}{\pi D * L} \text{ N/mm}^2$$

Where; P = Maximum load in "N" applies to the specimen
D = Measured diameter in "mm" of the specimen
L = measured length "mm" of the specimen.

Table 2 Split Tensile Strength (N/ mm^2) of concrete

DAYS	SAMPLE	SIZE πdl	LOAD (kN)	SPLIT TENSILE STRENGTH (N/mm^2)	AVERAGE SPLIT TENSILE STRENGTH (N/mm^2)
7	1	141300	160	1.13	1.18
	2	141300	170	1.20	
	3	141300	170	1.20	
14	1	141300	180	1.27	1.34
	2	141300	190	1.34	
	3	141300	200	1.42	
28	1	141300	210	1.49	1.60
	2	141300	230	1.63	
	3	141300	240	1.70	

4.2.3 Flexural Strength Test

All the specimens were tested in the Universal Testing Machine (UTM) of 1000 kN. After the curing period of 28 days was over, the beam washed and its surface was cleaned for clear visibility of cracks. The most commonly used load arrangement for testing of beams will consist of two-point loading. This has the advantage of a substantial region of nearly uniform moment coupled with very small shears, enabling the bending capacity of the central portion to be assessed. If the shear capacity of the member is to be assessed, the load will normally be concentrated at a suitable shorter distance from a support.Two-point loading can be conveniently provided by the arrangement. The load is transmitted through a load cell and spherical seating on to a spreader beam. This beam bears on rollers seated on steel plates bedded on the test member with mortar, high-strength plaster or some similar material. The test member is supported on roller bearings acting on similar spreader plates. The UTM must be capable of carrying the expected test loads without significant distortion. Ease of access to the middle third for crack observations, deflection readings and possibly strain measurements is an important consideration, as is safety when failure occurs.(Table.3)

Table 3 Flexural Strength (N/ mm^2) of concrete

DAYS	SAMPLE	LOAD (kN)	FLEXURAL STRENGTH (N/mm^2)	AVERAGE FLEXURAL STRENGTH (N/mm^2)
7	1	7	1.45	1.45
	2	7	1.45	
	3	7	1.45	
14	1	8	1.66	1.66
	2	8	1.66	
	3	8	1.66	
28	1	10	2.07	2.07
	2	10	2.07	
	3	10	2.07	

Flexural strength, $F = Pl/bh^2$ N/mm^2
Where, P= load in Newton shown in dial gauge
l= length of rectangular prism in mm i.e. 700 mm
b= breadth of rectangular prism i.e. 150 mm
h= height of rectangular prism i.e. 150 mm

5. RESULT AND DISCUSSION

5.1 General

The test result were the cubes, cylinders, beams in the compressive strength, split tensile strength and flexural strength test in the variation of results in graphs.

5.2 Compressive Strength Test

Totally twelve cube specimens were casted, after twenty eight days compressive strength of concrete tested. The test results were shown below Table 4 and Figure.3

Table.4. Compressive Strength Results

S.No	Percentage of pet fibre added	Average compression strength in 28 days (N/mm^2)
1	0	21.4
2	2	26.5
3	4	28.4
4	6	20.3

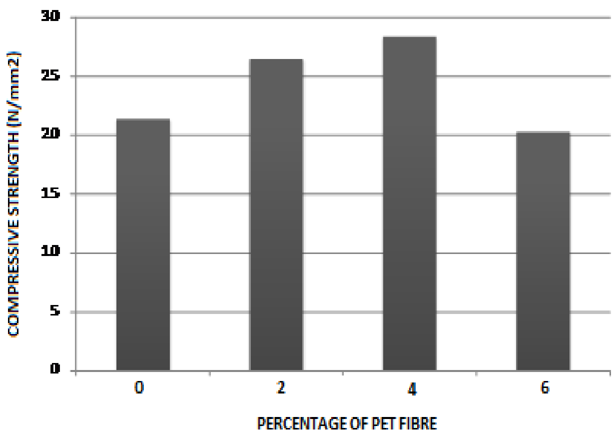

Figure 3 Compressive Strength Results

The compressive strength of concrete in the cubes were Tested. Then test results were compared. From the results, The 6% percentage of fibre used in cube it had low compressive strength compare to 0% percentage of fibre cube.

5.3 SPLIT TENSILE STRENGTH TEST

This cylinder specimen tested split tensile strength tested test results are shown in below Table 5 and Figure.4

Table 5 Split Tensile Strength Results

S .No	Percentage of pet fibre added	Average split tensile strength in 28days (N/mm^2)
1	0	2.6
2	2	2.95
3	4	3.1
4	6	2.8

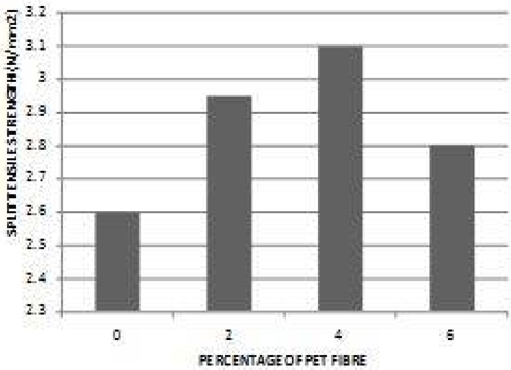

Figure 4. Split Tensile Strength Results

From split tensile strength of concrete were results of the 0, 2%, 6% of fibre added in to concrete, the split tensile strength high in 4 %, compared to without fibre concrete cylinder.

5.4 Flexural Strength Test

The beam specimens were tested the flexural strength test than the results were shown by Table 6 and Figure.5

Table 6 Flexural Strength Results

S.No	Percentage of pet fibre added	Average Flexural strength N/mm^2
1	0	2.57
2	2	2.59
3	4	2.61
4	6	2.55

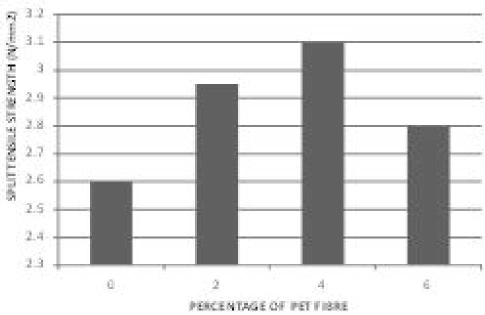

Figure. 5 Flexural Strength Results

6.CONCLUSION

An Experimental investigation was done to find the behaviour of PET fibre in concrete. The following percentages of PET fibres (0%, 2%, 4% and 6%) were added into concrete. It increases the flexural strength when added up to 4% compared to conventional concrete beam. For cubes and beams results with 6% of fibre, concrete strength decreased compared to conventional concrete. For cylinders up to 6% of fibre added, split tensile strength increased compared to conventional concrete. Deflection of the concrete beam decreased with the 4% of fibre. The fibre is compatible as a building material up to 4%. As a results show optimum percentage of 4% of PET fibres can be used as a building material.

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