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EXPERIMENTAL INVESTIGATION ON PROPERTIES OF CONCRETE WITH GRANULATED WASTE PET BOTTLE AS FINE AGGREGATE

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ABSTRACT

Waste plastic bottles are major cause of solid waste disposal. Polyethylene Terephthalate (PET, PETE or polyester) is commonly used for carbonated beverage and water bottles. This is an environmental issue as waste plastic bottles are difficult to biodegrade and involves processes either to recycle or reuse.

Today the construction industry is in need of finding cost effective materials for increasing the strength of concrete structures. This project deals with the possibility of using the waste PET bottles as the partial replacement of aggregate in Portland cement. Concrete with 2%, 4% and 6% PET bottle fibres for fine aggregate were produced and compared against control mix with no replacement.

Considerable researches and studies were carried out in some countries like USA and UK on this topic. However, there have been very limited studies in India on plastics in concrete.

Hence an attempt on the utilization of waste Poly-ethylene Terephthalate (PET) bottle granules as fine aggregate is done and its mechanical behaviour is investigated in compression, split tensile, flexural testing machine and fresh concrete test is also investigated

Keywords— PET bottle, plastic flakes, plastic fibres, compressive strength, % replacement.

1. INTRODUCTION

Concrete is the most widely used construction material due to its high compressive strength, long service life, and low cost etc. However, concrete has inbuilt disadvantages of low tensile strength and crack resistance also. The use of fibre reinforced concrete has increased in the last decade.PET is one of the most important and extensively used plastics in the world Waste is the one of the challenge to dispose and manage. It has one of the major environmental, economic and social issues.

Therefore, the waste bottle which challenge out in disposal can be binded out in concrete and disposal method which cause hazard to human being can be completely reduced and hence my project cover percentage replacement of fibre as fine aggregate.

1.1.Impact on environment due to plastic waste

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.

Considerable researches and studies were carried out in some countries like USA and UK on this topic. However, there have been very limited studies in India on plastics in concrete.

Hence an attempt on the utilization of waste Poly-ethylene Terephthalate (PET) bottle granules as fine aggregate is done and its mechanical behaviour is investigated in compression, split tensile, flexural testing machine and fresh concrete test is also investigated

2. OBJECTIVES OF THE PROPOSED PROJECT

The main objectives of this research proposal are to evaluate the possibility of using granulated plastic waste materials. The following were also proposed.

1. As partial substitute for the fine aggregate (sand) in concrete composites
2. To study the properties of PET.
3. To study the effect of PET over the compressive strength of concrete
4. To compare the strength of PET mix concrete with conventional concrete.
5. To determine the percentage of plastic fibre determines the strength

3. IMPORTANCE OF THE PRESENT PROJECT

The problem of disposing and managing solid waste materials in all countries has become one of the major environmental, economical, and social issues. A complete waste management system including source reduction, reuse, recycling, land-filling, and incineration needs to be implemented to control the increasing waste disposal problems.

Typically a plastic is not recycled into the same type of plastic products made from recycled plastics are often not recyclable.

So the main purpose of this project is to evaluate the possibility of using granulated plastic waste materials to partially substitute for the fine aggregate (sand) in concrete composites to decrease waste degrading our environment.

4. METHODOLOGY

1. To collect the PET bottles needed for research
2. To procure the equipment needed
3. Shredding the waste bottles into pieces
4. Granulating the pieces to smaller size as that of sand
5. Casting and curing of the basic test specimens(cubes, cylinders, prisms) for determination of strength
6. To test the structural models(RC beams with various percentage of plastic waste) for the results

4.1.Materials used

Cement: Ordinary Portland cement 53grade. Fine aggregate : River sand. Coarse aggregate: 20mm- 60% and 12.5mm - 40%. Plastic fibres : PET bottles.

4.2.Experimental plan

In this project, 2%, 4% & 6% of traditional fine aggregate is replaced for M40 grade concrete. The replacement percent is by volume of total aggregate content derived from the mixture proportioned.

Cube specimens of size 150 mm x 150 mm × 150 mm, cylinder specimens of 150 mm diameter and 300 mm height and prism specimens of size 100 mm × 100 mm × 500mm of 18 numbers each were casted for different proportions with PET bottles (grounded) and compared against a control mixture. Slump test was conducted on fresh concrete to determine the workability. The tests performed on hardened concrete after 7 and 28 days of curing were compression test, flexure test and split tensile

Fig No:1 Granulated PET bottle

5. MIX DESIGN

The mix design for M25 grade concrete is calculated using IS 456:2000, IS 10262:2009. The materials required as per design.

Table No: 1 Quantity of Material as per Mix Proportion

w/c ra	Quantity of Materials (Kg/m3)		
	Ce me nt	Fine aggr egate	Courseaggregate
0.4	463.5kg	4 5 0.4 k g	1 2 6 7 .4k g

The properties of materials used are

1. Specific gravity of cement = 3.15
2. Specific gravity of fine aggregate = 2.60
3. Specific gravity of coarse aggregate = 2.70
4. Water absorption
5. Coarse aggregate = 0.5%
6. Fine aggregate = 1%

5.1.Mix Proportions of plastic fibres

The mix proportion was done for various percentages of plastic fibres 2%, 4% and 6% replacement for fine aggregates. And the proportion are reduced from the natural fine aggregate and PET granules are replaced out. In such replacement the value are replaced under varying percentage in my projects

Table II Material Required As Per Mix Proportion

Plastic fibre %	2 %	4 %	6 %
Cement (kg/m^3)	4 63.5	4 63.5	4 63.5
Fine aggregate	4 4 1.3 9	4 3 2.3 8	4 2 3.3 7
Course aggregate	1 2 6 7 .4 .	1 2 6 7 .4	1 2 6 7 .4

TESTS ON SPECIMENS

% of PET bottle (Replacement fo	7 d a y s (N/mm^2)	1 4 d a y s (N/mm^2)	28 days (N/mm^2)
0	3 6 . 4 4	4 1 . 7 7	5 5 . 5 5
2	3 9 . 5 5	4 6 . 2 2	6 6 . 6 6
4	4 1 . 1 1	4 8 . 6 6	5 5 . 5 5
6	2 6 . 8 8	3 0 . 4 4	3 1 . 3 3

Mix ratio derived and mould out with various replacement of PET fibre as natural sand and casted into mould All the cast specimens were de-moulded after 24 hours and were placed in curing tank for a period of 7, 14, 28 days. The specimens were taken for testing such as compression test, split tensile strength test and flexure test. The specimens were tested in the universal testing machine.

Three numbers of specimens in each were tested and the average value is calculated. The results were compared and analysed with that of control mix.

The test set up and the failure pattern of specimens for Compression test, Split tensile test and Flexural strength test and the procedure were given below in detail.

i)Compressive strength test

The compressive strength of the cube specimen is calculated using the following formula:

Compressive Strength,

$fc=P/A\ N/mm^2$

Where

P = Load at failure in N

A=Area subjected to compression in mm^2

Fig,2 Compressive testing set up

Table III

Compressive strength between standard, 2%, 4%, 6% replacement of Bottle in concrete cubes

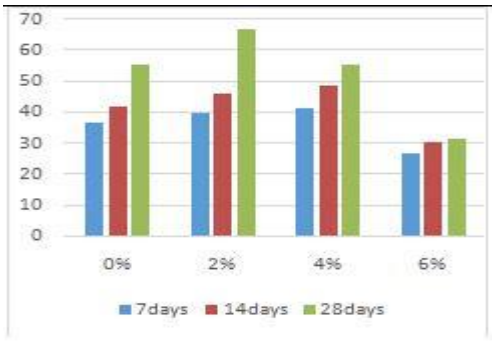

Chart 1 : Compressive strength on various concrete ratio

ii) Split tensile strength test

The split tensile strength of the cylinder specimen is calculated using the following formula:

Where,

P = Load at failure in N

L = Length of the Specimen in mm d **=** Diameter of the Specimen in mm

Fig No: 3 Split Tensile set up

Table IV Comparison of Split tensile strength between standard, 2%, 4%, 6% replacement of Bottle in concrete cubes

% of PET bottle (Replacement fo	7 d a y s (N/mm^2)	1 4 d a y s (N/mm^2)	28 days (N/mm^2)
0	3 . 2 5	3 . 5 3	4 . 5 2
2	3 . 9 6	4 . 1 7	4 . 9 5
4	3 . 2 5	3 . 6 0	3 . 8 9
6	1 . 8 3	2 . 4 7	2 . 6 1

Chart 2: Split tensile strength on various concrete ratio

iii) Flexural test

The Flexural Strength of the specimen was calculated by using the formula

fb = $\frac{pl}{bd^2}$ N/mm²

Where,

P = Load at which specimen fails l
= Effective span in mm

b = Breadth of the specimen in mmd d = Depth of specimen in mm

Fig No: 4 Flexural Test set up

Table IV Comparison of flexural strength between standard, 2%, 4%, 6% replacement of Bottle in concrete cubes

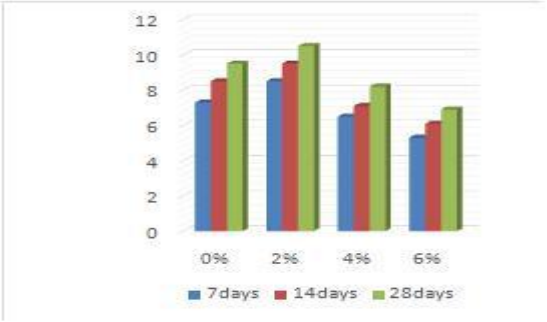

Chart 3: Flexural strength on various concrete ratio

6. CONCLUSION

1. The concrete with PET fibres reduced the weight of concreteand thus if mortar with plastic fibres can be made into light weight concrete.
2. It was observed that the compressive strength increased up to 2% replacement of the fine aggregate with PET bottle fibres and it gradually decreased for 4% and 6% replacements. Hence replacement of fine aggregate with 2% replacement will be reasonable.
3. It was observed that the split tensile strength increased up to 2% replacement of the fine aggregate with PET bottle fibres and it gradually decreased for 4% and 6% replacements. Hence, the replacement of the fine aggregate with 2% replacement will be reasonable with high split tensile strength compared to the other specimens casted and tested.
4. It was observed that the flexural strength increased up to 2% replacement of the fine aggregate with PET bottle fibres and it gradually decreased for 4% and remains the same for 6% replacements.
5. Hence, the replacement of the fine aggregate with 2% of PET bottle fibres will be reasonable than other replacement percentages like 4% and 6% as the compression and split tensile strength reduces gradually.
6. Concrete mixed with waste PET fiber is eco-friendly, non-hazardous as it easily get dispersed in concrete mix and could be adoptable in any environment
7. Hence concrete with waste PET fiber can be used as an effective plastic waste management practice in future and reduces the waste plastic rulin our environment

6.1.Environmental benfits in using waste plastic:

As per the estimates, India produces 500,000 tons of pet waste every year and due to increasing use of pet bottles in dailyAt present, the total recycling capacity in India is around 145,000 TPA, out of which Reliance Industries Ltd. has a capacity of 42,000 TPA and Kanpur-based Ganesh Polytex Ltd (GPL) has a capacity of around 39,600 TPA and rest is with other small local players

As such quantity of waste need to have large area of landfill to dump it, its use in concrete mix will prove a better option for land fill that, being non-degradable, remain for long years and cause problem before us. Concrete is the most widely used construction material in the world due to its high compressive strength, long service life, and low cost.

Nowadays, unfortunately, the recycling rate of PET bottles is much less than the sales of virgin PET production for common uses. This gap is dramatically increasing, pushing towards finding a solution of this problem and a higher recycle of PET. Particular interest is stirring, at present, the use of fibers obtained from waste PET bottles.

A possible application is to utilize waste PET fibers as replacement of fine aggregates in concrete.

6.2. SCOPE FOR FUTURE STUDIES

1. Admixtures can be used to improve bonding of fibres.
2. Utilisation of fibres in plastic concrete in various proportions to improve the strength.
3. Plastic fibres along with steel fibres can be used to improve the strength of concrete.
4. A better way of grinding plastic bottles may be adopted to produce fibres in large scale.

7. REFERENCE

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