Experimental Investigation on the Properties of Concrete with Plastic PET (Bottle) Fibres as Fine Aggregates

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Abstract: ***The Disposal of large quantity of plastic cover may cause pollution of land, water bodies and air. The proposed concrete which is made up by adding plastic in concrete may help to reuse the plastic cover as one of the constituents material of concrete, to improve the certain properties of concrete. The properties of concrete as varying percentages of plastic will test for compressive strength and Split tensile strength and flexural strength shows that an appreciable improvement in tensile strength of concrete can be achieved by introducing cut pieces of plastic cover. This paper presents the experimental investigation of feasibility of polythene cover post consumer waste used for food packaging. The numbers of samples is prepared in M25 concrete mix with required water/ cement ratio. Plastic waste was converted in to fiber size form and added waste for three aspect ratios, is casted into desire shape and size as per requirement of the tests. Each specimen was cured for 7 days, 14 days, and 28 days. The workability of compression, tension and flexural tests were carried out. The results are compared with normal concrete was observed.***

Keywords: Compressive strength split tensile strength, PET bottle, plastic flakes, plastic fibres, plastic cover, and environmental problems.

1. Introduction

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 percent every year. Plastics constitute 12.3 percent 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[1] as fine aggregate is done and its mechanical behaviour is investigated.

2. About the Project

A. Objectives of the Proposed Project

The main objectives of this research proposal are to evaluate the possibility of using granulated plastic waste materials [2]. The following were also proposed.

- As partial substitute for the fine aggregate (sand) in concrete composites
- To investigate the structural behavior of such replaced concrete components
- To investigate the mechanical behavior of the components by using fibers.
- To determine the percentage of plastic fibre which gives more strength when compared to control concrete.

B. 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. The use of biodegradable plastics is increasing. If some of these get mixed in the other plastics for recycling, the reclaimed plastic is not recyclable because the variance in properties and melt temperatures.

The 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. The polyethylene (PET) bottle which can easily be obtained from the environment with almost no cost is shredded and added into ordinary concrete to examine the strength behaviour of various specimens[3].

Thermal insulation enhancement in concretes by adding waste PET and rubber pieces can also be studied. Also the plastic waste is found to have no water absorption (based on literature) and hence corrosion control analysis can be done.

The products which are aimed in this project really have a commercial value since there is a need for alternate materials for construction. The PET concrete blocks which can be used for masonry works will have more commercial value like Hollow blocks ad Fly ash blocks. Also the light weight wall panels and balusters will attract more attention of the construction industry.

C. Methodology

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

The flow chart shown in Figure 1 illustrates the methodology of the project.

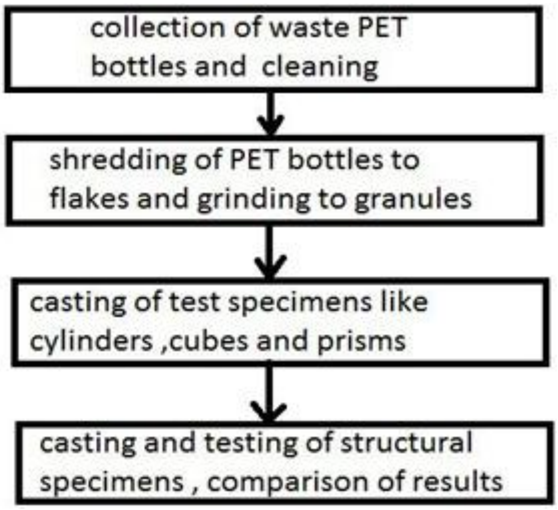

Figure 1: methodology of the project

D. Materials used

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

E. Experimental plan

In this project, 0.5, 1, 2, 4 and 6 percent of traditional fine aggregate is replaced for M25 grade concrete. The replacement percent is by volume of total aggregate content derived from the mixture proportioned [4].

Cube specimens of size 150 mm 150 mm 150 mm, cylinder specimens of 150 mm diameter and 300 mm height and prism specimens of size 100 mm 100 mm 500 mm of 18 numbers each were casted for different proportions with PET bottles (grounded) and compared against a control mixture [5]. 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 test.

The collected waste PET bottle flakes are shown in Figure 2 and the plastic fibre (ground) is shown in Figure 3.

Figure 2: PET bottle flakes

Figure 3: Plastic fibres

F. The mix design

The mix design for M25 grade concrete is calculated using IS 456:2000, IS 10262:2009. 44

MATERIALS REQUIRED AS PER IS METHOD OF DESIGN The properties of materials used are: Specific gravity of cement = 3.15

Specific gravity of fine aggregate = 2.60 Specific gravity of coarse aggregate = 2.60 Water absorption Coarse aggregate = 0.5percent Fine aggregate = 1percent

Figure 4: Compression test set up

Figure 5: Split tensile test set up

3. Experimental Procedure

A. Tests on specimens

All the cast specimens were de-moulded after 24 hours and were placed in curing tank for a period of 7 to 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 are shown in Figure 4, Figure 5 and Figure 6 respectively.

B. 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

The graph shown in figure 5 illustrates the variation of the compressive strength of specimens with different replacement percentage of fine aggregates by plastic PET fibres.

Figure 6: Flexural strength test set up

An appreciable increase in the compressive strength is observed [6] till 2percent replacement of the fine aggregate with PET bottles fibres and then the compressive strength is gradually reduced.

The replacement of fine aggregate with 2percent replacement is found to be reasonable.

C. Split tensile strength test

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

Split Tensile Strength, fsp =

$$fsp = 2\ P= {}^{Y} L\ \ d;\ N=mm^2 \quad (1)$$

Where, P = Load at failure in N

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

The split tensile strength of the cylinder is seen to be increasing [6] till the 2percent replacement of the fine aggregate with PET bottle fibres and then decreases slightly with increase in the replacement of the fine aggregate.

The replacement of the fine aggregate with 2percent replacement is found to be reasonable with high split tensile strength compared to the other percentages.

D. Flexural strength test

The flexural strength of the prism specimen is calculated using the following formula:

The flexural strength when a >13.3 cm for 10 cm specimen,

$$f_b = \frac{P\ a}{b\ d^2} \quad (2)$$

The flexural strength when a <13.3cm for 10 cm specimen,

$$f_b = \frac{3\ P\ a}{b\ d^2} \quad (3)$$

Where, b = measured width of specimen in cm

d = measured depth in cm of the specimen at the point of failure.
a = distance of the crack from the nearer support in cm P= maximum load in Kg applied to the specimen.

The flexural strength of the specimens with replacement of the fine aggregate with the PET bottle fibres increases gradually with the increase in the replacement percentage [6] but it may fall for more replacement percentage as it is somewhat same for the 4 and 6 percent.

The replacement of the fine aggregate with 2percent of PET bottle fibres will be reasonable than other percentages.

4. Conclusion

The concrete with PET fibres reduced the weight of concreteand thus if mortar with plastic fibres can be made into light weight concrete based on unit weight [7].

It was observed that the compressive strength increased up to 2percent replacement of the fine aggregate with PET bottle fibres and it gradually decreased for 4 and 6 percent replacements. Hence replacement of fine aggregate with 2percent replacement will be reasonable.

It was observed that the split tensile strength increased up to 2percent replacement of the fine aggregate with PET bottle fibres and it gradually decreased for 4 and 6 percent replacements. Hence, the replacement of the fine aggregate with 2percent replacement will be reasonable with high split tensile strength compared to the other specimens casted and tested.

It was observed that the flexural strength increased up to 2percent replacement of the fine aggregate with PET bottle fibres and it gradually decreased for 4percent and remains the same for 6percent replacements.

Hence, the replacement of the fine aggregate with 2per-cent of PET bottle fibres will be reasonable than other replacement percentages like 4 and 6 percent as the compression and split tensile strength reduces gradually.

5. Future Work

Admixtures can be used to improve bonding of fibres. Utilization of fibres in plastic concrete in various proportions to improve the strength.

Plastic fibres along with steel fibres can be used to improve the strength of concrete. A better way of grinding plastic bottles may be adopted to produce fibres in large scale.

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