Usage of Waste PET Bottles Replacing Fine Aggregates in Concrete with Marble Dust as Additive – A Review

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Abstract— PET (Polythene Terephthalete) is the most used crude material for mineral water bottles, soft drink bottles, soda bottles and other shopper materials. After usage these PET bottles becomes waste and very difficult to dispose as these are disposed by burning and so causes environmental pollution and degradation. So there is a requirement of the solution to this problem. Researchers have shown a solution for reducing these wastes and using it for concrete so that waste minimization can occur. A solution to reduce the wastage is use of PET in concrete by replacing it with fine aggregates. Most of the researchers used it as PET fibres as replacement of fine aggregates in concrete. Previous studies show that it improves the properties of concrete as strength improves. Researcher studies also show that the use of PET can be effectively done by changing its shape and size. Also marble dust increases the strength in concrete. This study focuses on use of PET as flakes in concrete by replacing it with fine aggregates from 4% to 16% and to improve the strength characteristics marble dust used as an admixture in it.

Key words: Waste PET, Concrete, Compressive Strength

I. INTRODUCTION

Plastics are the most widely used material in our daily lives. It has properties like low density, high strength, user friendly designs, fabrication capabilities, long life, light weight and low cost [15]. Plastic wastes are non-biodegradable which causes a lot of environmental problems. 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 [6].

In the plastic waste, polyethylene forms the largest fraction, which is followed by Polyethylene terephthalate (PET) that represents one of the most common plastics in solid urban waste [15].A very large amount of PET has been used in packaging application and achieves acceptance playing a growing role in the use of PET in whole world [10]. The disposal of PET waste is a major problem now a days as these are dumped into the landfills and disposed of by burning which causes major problems to the environment because of its non-biodegradable nature. Recycling of waste PET bottle is one of the way to reduce the environmental impact but it is difficult and labour intensive to sorting of plastic waste [17]. Concrete is the most widely used material in construction all over the world. Waste disposal has become one of the major environmental, economic and social issues. The waste plastic is being among the most prominent, waste polyethylene terephthalate (PET) bottles are recycled and used for different purposes. The use of plastic in concrete helps to improve the basic properties of concrete. The main advantage of using plastics in concrete is its durability resistance to chemicals and light weight [13]. In field of concrete technology India as well as other nation now is seeking for alternative for conventional aggregate so plastic waste may be recognized as one of alternatives. As per the estimates, India produces 500,000 tons of pet waste every year and due to increasing use of pet bottles in daily consumption the amount of waste is going to grow by leaps and bounds [15]. So the use of PET waste in concrete is a method to reduce the waste and environmental degradation. Also concrete's strength improvement and natural resources sustainability takes place by the use of PET in concrete and PET produces the light weighted concrete. Various researches shows improvement in the concrete's properties as per the addition of PET into the concrete, most of them are added as fibers as per literature review but in this study PET will be added as flakes for testing the improvement in concrete's properties. Also in this study marble dust can be used as it also helps to increase the strength of concrete. It can be used as a additive for increasing concrete's strength to the replacing fine aggregates with PET as per a little percentage of addition in the design mix, as marble dust is added to the concrete, it increases the compressive strength up to 50% replacement with fine aggregates [20].

II. OBJECTIVE

- The main objective of the study is to improve the concrete's properties.
- To find out the compressive, flexural and tensile strength of concrete with replacement of fine aggregates to PET with different ratios of addition.
- To improve the strength characteristics by the addition of marble dust as an additive or admixture to PET concrete.
- Waste minimization and reducing the environmental degradation caused by PET burning and landfills.

III. LITERATURE REVIEW

The various researches and their results for the use of PET bottles as replacement of fine aggregates are as follow:-

Sr.No.	Author/References	Method employed	Findings
1	Vali N and Asadi (2017) [9]	Fine aggregates replaced by PET fibers and PET flakes by 5%,10%,15% and 20%.The aim is to decide ideal quality and impact of utilization of reused PET as fractional substitution of fine total in common Portland bond.	Compressive strength expanded up to 10% replacement with fine aggregates and goes on decreasing with further replacement. PET reduces the unit weight and forms light weighted concrete

2	Shubbar and Al-Shadeedi (2017) [18]	More than 30 cubes and 30 cylindrical specimens were prepared by replacing PET Pellets in four mixing values of 1%,2%,4% and 8%.Aim is to find out the difference between various properties like dry & fresh density test slump test, compressive strength, split tensile strength with replacement of PET granules and conventional concrete	With mixes containing 1%, 2%, 4% and 8% waste PET exhibiting slumps 14%, 22.6 %, 37.4% and 61.7 % lower than that of the control. PET replacement level of 1%, 2%, 4%, and 8%, a decrease by 0.5 %, 2.8 %, 7.3 % and 9 % in fresh density and at a level of 0.15%, 2.3%, 6.5%, and 8.8% for dry densities when compared to the reference mix. Compressive strength and split tensile strength increases up to 2% addition
3	Alsadey (2016) [16]	Plastic bottle fibers were added form 0 to 3% to the concrete Slump test was taken with the addition of fibers, Compressive strength was also tested with the addition of PET fibers to the concrete	From the slump results obtained plastic bottle waste fiber have a significant decrease in slump compare to the results in plain concrete. The maximum increase in the characteristic strength is observed in 1.5% added criterion for the concrete mix
4	Verma and Arora (2015) [15]	Replacement of fine aggregates with PET fibers takes place as ratio of 2%, 4%, 6% and 8%, Test cubes were taken under compressive testing machine and load applied gradually at rate of 1.4 to 2.1 MPa/min till specimen fails	With the replacement of fine aggregates with waste PET fiber, there is increase in compressive strength up to 2% replacement, at which there is 12% increase in compressive strength. For percentage replacement more than 2% there is decrease in compressive strength.
5	Magalhães, and Fernandes (2015) [7]	This paper addresses the results of an investigation on the influence of Recycled PET (R-PET) fibers as reinforcement of cementitious matrix. The mixtures were produced using Portland cement, fly ash, silica sand, super plasticizer and different volumes of R-PET fibers, i.e. 0%, 1.0%, 1.5% and 2.0%.	The use of Recycled PET (R-PET) fibers, as reinforcement of cement composites, is a promising technique for developing sustainable materials to be applied in the civil construction industry
6	Nibudey et. al (2014) [13.a]	This paper presents experimental results of compressive strength and sorptivity for normal concrete and PET fiber reinforced concrete (PFRC).In this experiment M20 and M30 grade of concrete and two fiber geometry of aspect ratios 35 and 50 with fiber volume fractions 0.0 to 3.0% were used.	After 28 days it has found that compressive strength of PFRC increased and the sorptivity decreases. Strength increased only up to 1% fiber content for both the grades. Slump and compaction factor tests shows that workability has been reduced in PFRC due to resistance offered by fiber.
7	Prabhu et. al (2014) [12]	This paper deals with the possibility of using the waste PET bottles as the different aspect ratio of 17, 33, 50, size of fiber added in to the concrete with 0.5%, 1%, and 1.5% PET bottle fibers for fine aggregate were produced and compared against control mix with no replacement.	The optimum percentage addition for increase of strength is 1%. PET fibers increased both ductility and energy absorption of the axially compressed concrete samples. From this experimental project work about 30-35 % strength of concrete will be increased.
8	Fraternali et. al (2014) [2]	This paper gave experimental study on the mechanical properties of recycled polyethylene terephthalate fiber-reinforced concrete (RPETFRC) and tells about durability in an aggressive seawater environment. Recycled PET fibers are used in this paper with concrete mix in some proportions.	The R-PET fiber reinforcement of concrete is highly beneficial in terms of the energy absorption capacity of the material. PET fibers appear to be highly beneficial in terms of compressive and tensile strength properties in the case of pozzolana cement based concretes with a high water/cement ratio (0.53).
9	Nibudey et. al (2014) [13.b]	In this paper the shear strength of waste plastic fiber reinforced concrete is taken into consideration. The concrete of M20 and M30 grades were selected for the study. The PET fibers were obtained from used mineral water bottles, without	The shear resistance of plastic fiber reinforced concrete (PFRC) was found to be increased. The maximum increased in shear strength of PFRC was 27.25% for M20 grade of concrete .The ductility was found to be increased in PFRC as compared to the normal concrete.

		any processing, of two sizes with aspect ratios 35 and 50.	The maximum percentage of increase in compressive strength is at 1% fiber addition.
10	Maruthachalam and Muthukumar (2013) [8]	Recycled Polyethylene Terephthalate fibers will be added in harden concrete for various volume fractions such as 0.1%, 0.2%, 0.3%, 0.4% and 0.5% with 0.5% of steel fiber by total volume of concrete. Compressive Strength, Flexural Strength and Split Tensile Strength tests had been conducted in this research	The Compressive Strength found to be increased for all the specimens i.e 0.1%, 0.2%, 0.3%, 0.4% and 0.5%, Flexural Strength found to be increased till 0.3% and then decreases and constant for 0.4% and 0.5% ,Split Tensile Strength goes on increasing till 0.3% and decreases for above percentage as compared to normal concrete.

IV. MATERIALS & METHODOLOGY

A. Cement

Cement used should be OPC cement conforming to IS 8112-1982.The properties of cement are as follows:-

Type and Grade	Ordinary Portland Cement Values
Bulk density	1450kg/m^3
Soundness	Expansion 5mm
Initial Setting Time	30 min
Final Setting Time	600 min
Specific Gravity	3.15

Table 1: Properties of cement [15]

B. Aggregates

The size of coarse aggregates should be 20 mm and that of fine aggregates are of Zone II and all the properties should conform to IS: 383-1970.

Aggregates	Fine Aggregates	Coarse aggregates
Type	River sand (Zone II)	Crushed granite
Maximum nominal size	Less than 4.75	20mm
Bulk density(kg/m^3)	1700	1800
Free surface moisture (%)	2.0	1.0
Specific gravity	2.60	2.65
Fineness modulus	2.3	6.0

Table 2: Properties of Aggregates [15]

C. PET Bottles

PET bottles can be easily collected from the landfills and dumped areas or from the recycler units of PET and then send for grinding it to the size less than 4.75mm as it is to be replaced with fine aggregates so size and other properties should be similar to the fine aggregates.

D. Water

Water used be fresh, free from organic materials and clean. Most of the times water used is tap water.

V. METHODOLOGY

Design mix should be done as per IS 10262:2009 and all the quantities would be added in to the mixer according to that requirement. Casting of Cubes, Cylinders and Beams will be prepared for the compressive, flexural and split tensile strength testing with the addition of PET granules at different ratios of 4%, 8%, 12% and 16% respectively with marble dust as 2% additive to all. The size of cube is 150mmX150mmX150mm, the size of cylinder is 150mm x 300mm and the size of beam is 100mmX100mmX500mm. Mixing of concrete will be carried out in a mixer. The concrete casted in all the moulds should be compacted with tamping rods. After that, it should kept on a vibrating table to remove all the air voids. The specimens would be demoulded after 24 hours and cured for 28 days in curing tanks. After 28 days of curing, the specimens all taken out of the curing tanks and then tested for various strengths like compression test, flexural strength test, split tensile strength.

VI. CONCLUSION

Researches showed the following conclusion:

1) PET fibre usage gives maximum strength by 10% replacement of fine aggregates with it.
2) PET can be used as flakes with replacement of fine aggregates as size and shape of PET in concrete effects the strength improvement.
3) Marble dust increases the strength in concrete so it can be used as additive in the PET concrete.

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