Use of PET bottle shredding as a substitute to fine aggregate in Concrete

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***Abstract* - The increase in population over the decades has resulted in a rapid increase in the need of goods of various kind and material, plastic being the most heavily used. The plastic bottles used in carbonated beverages, packaged drinking water bottles, jugs, etc. are made of PET (Polyethylene Terephthalate) constitute of a very large proportion of plastic waste and is harmful for the environment for various obvious reasons. This project mainly concentrates on reusing of PET bottle waste as a partial replacement of fine aggregate in concrete. Fine aggregate is replaced with PET bottle shredding in 5%, 7.5%, 10%, 12.5%, and 15% and used to prepare M20 and M25 grade concrete mix with and without plastics and tests on concrete like slump, cube tests: compression test and flexural tensile strength test are performed to understand their behavior and usefulness as replacement.**

***keywords* - PET plastic, cement, fine aggregate, PET bottle shredding**

I. INTRODUCTION

Human beings are the most dominant and intelligent creatures to roam on earth. Humans being intelligent and most evolved species are able to reach to a point where we live a comfortable life. Due to this human has grown greedy and there needs are very high.

Due to this, need for various goods and supplies are necessary and a very important part of our lives. Industrialization and advancement in science has led us to produce various things which are manufactured form both renewable and non-renewable resources. But over the last century, with a rise in population and new inventions in the field of science, the production rate of goods has skyrocketed. This has led us to a luxurious lifestyle. But this has also led us to a very huge and inevitable problem, waste management.

Today, a huge proportion of the manufactured goods are made from plastic which is considered a very useful and important invention in the history of science. Plastic has many uses but one can never ignore the fact that plastic is a non-biodegradable substance, i.e., it cannot be destroyed or decomposed easily. In fact plastic takes 1000 years to degrade. Over this long period of time, plastic continuously pollute the environment.

In the modern times, industries like carbonated drink manufacturers, food packaging, packaged drinking water industries use PET plastic. PET plastic is a common name to Polyethylene Terephthalate which is a type of plastic which is light weight, clear looking, and durable plastic.

Due to the rapid increase in the use of PET bottles, solid waste problem is raised. It is known that a long time is needed to degrade the waste PET bottles in the nature. Therefore, one of the reasonable methods for disposal of PET wastes, which causes environmental pollution is using these wastes in Civil engineering construction in some form.

In the recent years, a lot of experimental studies were carried out on how to properly dispose and reuse the PET plastic so as to reduce the harsh effect on environment.

Construction industry is a huge industry which consumes a lot of natural resource can be made a possible source of plastic reuse. Waste plastic can be made useful in construction industry which would have a number of benefits, biggest benefit being plastic waste reuse and conservation of natural resources.

The main aim of this study is to investigate the influence of the use of shredded waste PET shredding on the properties of concrete. This is achieved by examining physical and mechanical properties of concrete containing PET aggregates. M20 and M25 grade concrete mixes as per the IS 456:2000 are prepared with partial substitution of fine aggregate with PET bottle shredding and are tested for their compressive and flexural tensile strength.

II. LITERATURE REVIEW

One of the main environmental problems today is the disposal of waste plastic. The use of plastic in various places such as bottles, polythene sheets, containers, etc. are increasing day by day.

This results in increase in the production of plastic waste which harms the environment.

- Dr. S. Chandrakan, 2004, has done a research on "Use of plastic shreds in concrete" to study the suitability of the use of plastic spreads as fibers in concrete.
- The properties studied included compressive strength and flexural strength under cyclic loading process. The results have shown that the improvement of concrete properties at lower cost is obtained with plastic shred reinforced concrete to some extent.
- B. Venkat Narsimha Rao has done research on "Reuse of polyethylene plastic waste in concrete".

- Plastic used in various ways in society which is useful but at the same time it has adverse effect on environment. Plastic bottles, PET bottles, plastic bags, and other forms of usable plastic last for 1000 years and pollute the environment.
- The proposed concrete which is made up by adding plastic waste may help to reduce the pollution in environment to some extent and this may help to increase the properties of concrete. The properties of concrete vary with the percentage of plastic added into it.
- Naveen Lasiyal has done research on "Effects of plastic waste as Partial replacement of fine aggregate in concrete and cost analysis".
- It was seen the compressive strength and flexural strength changes with the percentage replacement of plastic (PET bottle shredding) by fine aggregate.
- The concrete with plastic (PET bottle shredding) decreased the weight of concrete and cost reduction in cost of project and thus, if mortar and plastic fibers can be made into light concrete based as unit weight.

However, in the present project only mechanical properties of the concrete mixed with PET plastic waste are investigated.

III. OBJECTIVE

India is a big country with major population living in rural areas. But with the growing rate of development in both rural and urban India has increased manifolds over years. India has a huge population and is about to top the list of most populated countries in near future by beating China in population war. Due to this and also India being a developing country, Indian concrete industry is a very important industry.

But since, concrete is prepared with cement, fine aggregate, coarse aggregate, admixtures, water, the majority of the components and materials used to prepare concrete are non- renewable resources, i.e., they are present is a limited quantity and are most likely to be exhausted.

The main objective of this project is to carry out an experiment with the aim to find wether plastic waste, which otherwise pollute the environment, can be used to replace the fine aggregate in small percentage. This will ensure a reuse to the plastic waste and also will help in saving the non-renewable resources.

The plastic used in the project is Polyethylene Terephthalate or generally known as PET plastic. This type of plastic is generally used to manufacture plastic bottles used in carbonated beverage industry and packaged drinking water industry.

IV. METHODOLOGY

1. Material used:
   i) PET bottles shredding
   ii) Fine aggregate (river sand)
   iii) Cement OPC 53 grade
   iv) Coarse aggregate: 20mm and 10 mm
2. Procedure:
   In this project two different grades on concrete M20 and M25 are prepared. The fine aggregate i.e. river sand is replaced with PET bottle shredding in percentages 5%, 7.5%, 10%, 12.5%, and 15% by volume. These batches are then used to prepare concrete cube specimen of dimensions 150mm x 150mm x 150mm. cube batches with no PET shredding are also prepared.
   These cubes are then allowed to cure for a time span of 28 days.
   Tests like compression test and flexural tensile strength test are then performed on the cube specimen at time intervals 7 days, 14 days and 28 days and the results are compared to the pure concrete cube's test results.

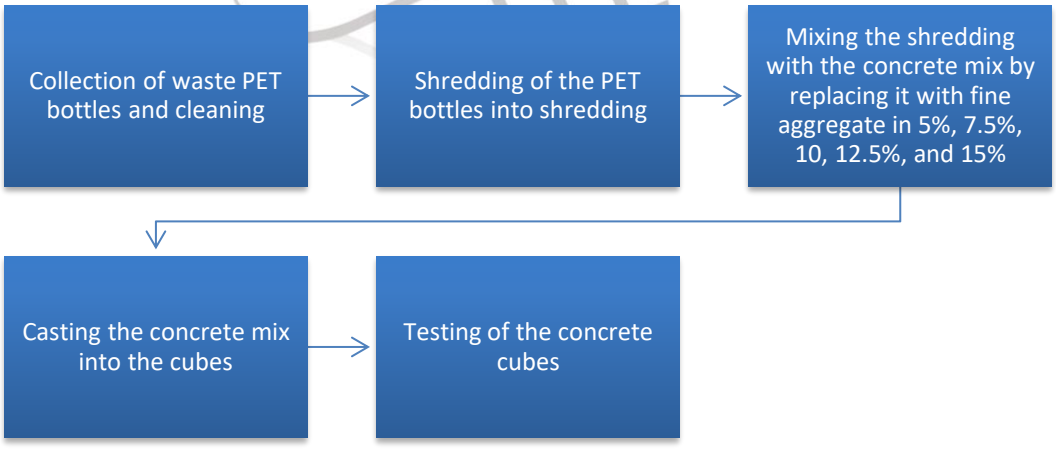


Figure 1. - Procedure steps

3. Optimal mix:
   Optimal mix for standard guidelines are referred in IS 456:2000
   The blended mix for M20 and M25 grade concrete according to IS 456:2000 in this paper.

4. Specific gravity:
   i) Cement: 3.15
   ii) Fine aggregate: 2.64

iii) Coarse aggregate: 2.84

5. Concrete used:
M20 grade concrete

w/c ratio	Cement	Fine aggregate	Coarse aggregate
0.5	360 kg/m3	584 kg/m3	1223.8 kg/m3

Table 1. - M20 grade concrete

M25 grade concrete

w/c ratio	Cement	Fine aggregate	Coarse aggregate
0.5	448.6 kg/m3	752 kg/m3	1150 kg/m3

Table 2. - M25 grade concrete

6. Plastic fiber mix:
Plastic fiber mix was performed for predetermined percentage of fibers i.e. 5%, 7.5%, 10%, 12.5%, 15%.

The M20 mix as per guidelines is given in the table below-

Material (Sand)	PET bottle waste (%)				
584 kg/m3	5%	7.5%	10%	12.5%	15%
	554.8	540.2	525.6	511	496.4

Table 3. – Plastic fiber mix for M20 grade concrete

The M25 mix as per guidelines is given in the table below-

Material (sand)	PET bottle waste (%)				
	5%	7.5%	10%	12.5%	15%
752 kg/m3	714.4	695.6	676.8	658	639.2

Table 4. – Plastic fiber mix for M25 grade concrete

V. TEST TO BE PERFORMED ON CONCRETE

- Slump cone test:
Slump cone test is a test for consistency of concrete. It is performed to check the workability of concrete as it is a very important property of concrete. According to the experiment, the slump type of the concrete grades M20 and M25 was found to be true slump. The observations and results are as follows

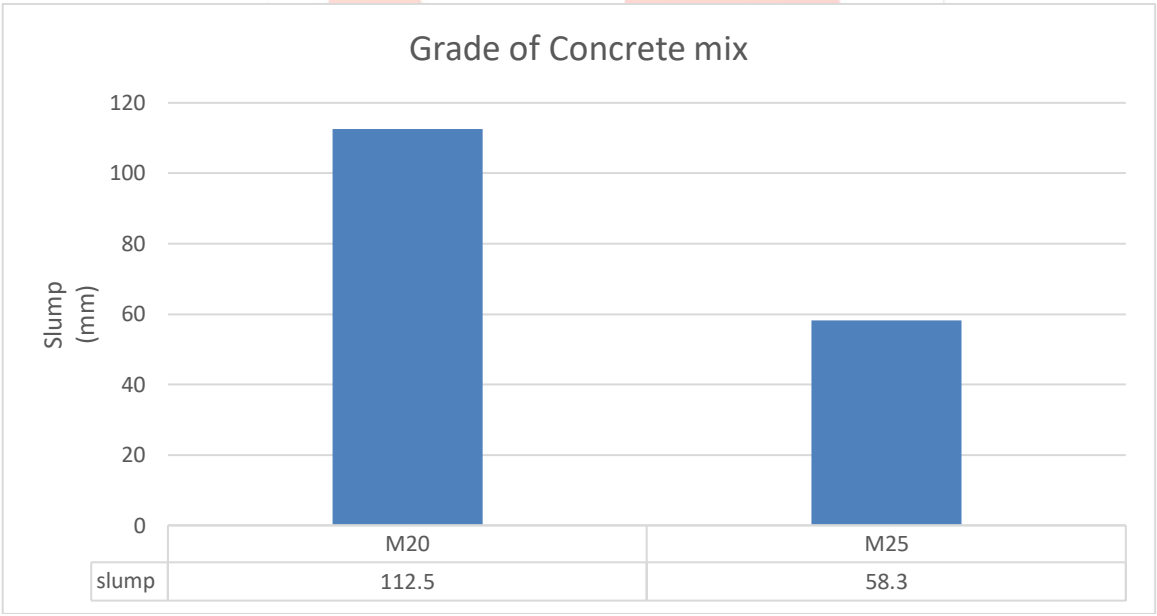
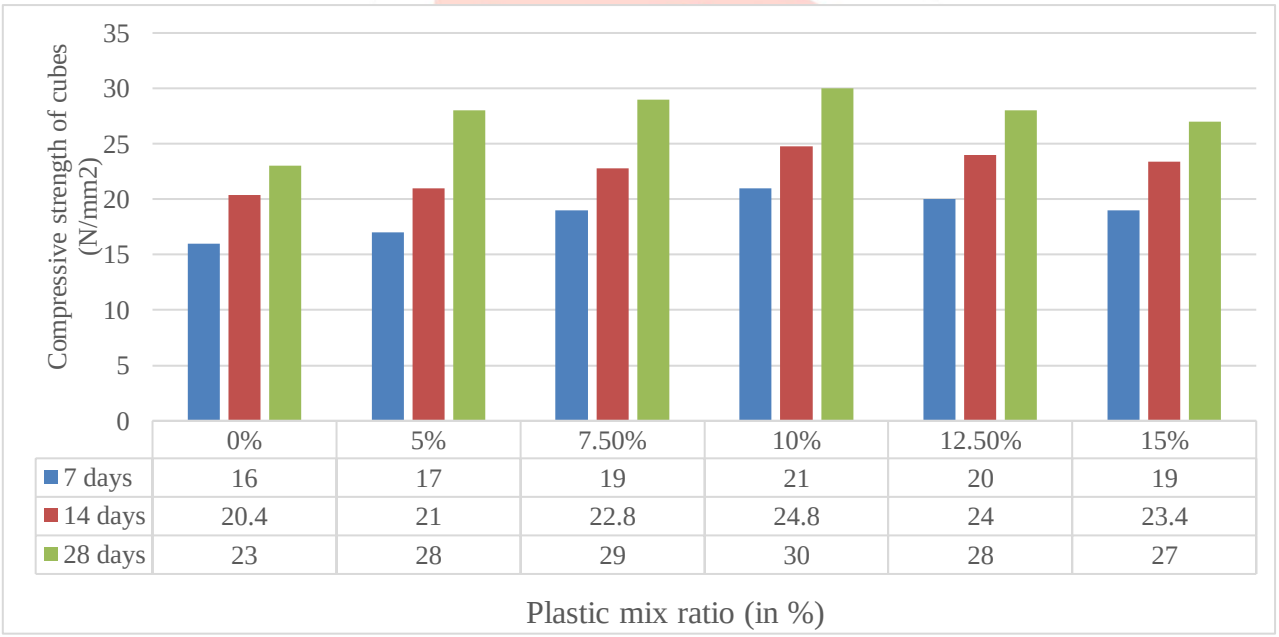


Figure 3. – average slump height on addition of percentage of plastic (5%, 7.5%, 10%, 12.5%, 15%) in M20 and M25 grade of concrete.

- Compression strength test:
The specimen prepared with plastic fiber mix is casted in cubical structure of dimension 150mm x 150mm x 150mm.
Compressive strength of concrete is the strength of hardened concrete measured by the compression test.
The compressive strength of 150mm x 150mm x 150mm size cube is tested at 7 days, 14 days, 28 days.

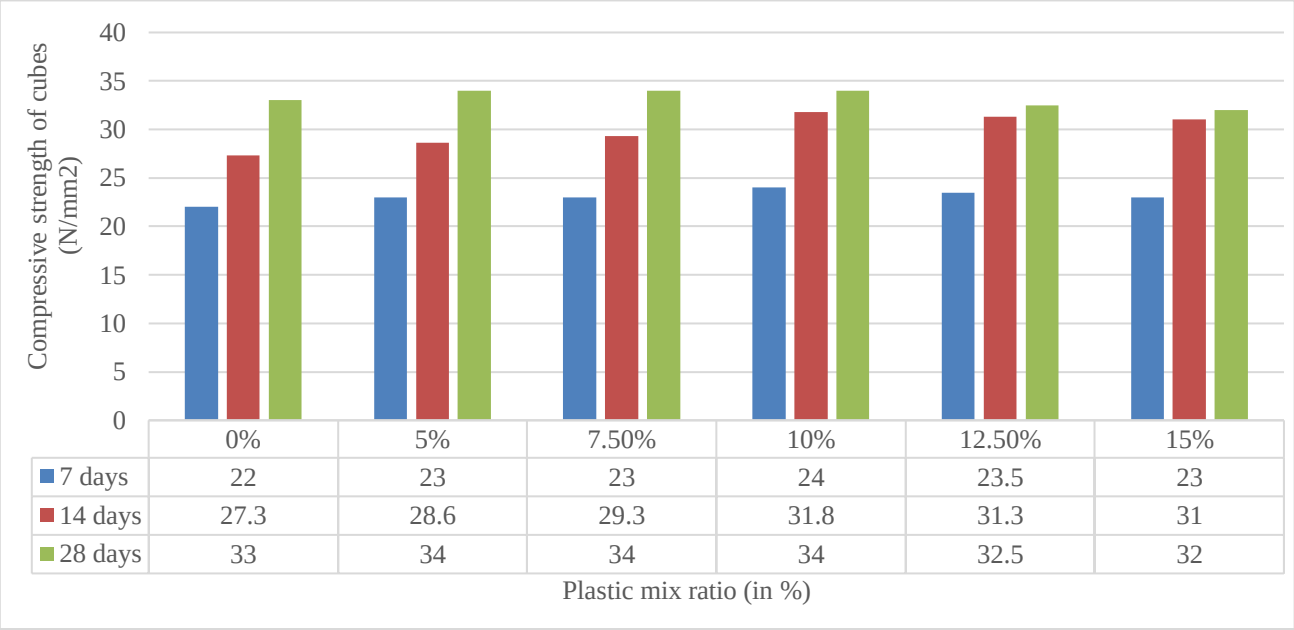
Figure 4. – Concrete subjected to loading

Compressive strength of concrete = maximum load carried by specimen / total surface are of specimen



	0%	5%	7.50%	10%	12.50%	15%
7 days	16	17	19	21	20	19
14 days	20.4	21	22.8	24.8	24	23.4
28 days	23	28	29	30	28	27

Figure 5. – Compressive strength test results for M20 grade concrete mix



	0%	5%	7.50%	10%	12.50%	15%
7 days	22	23	23	24	23.5	23
14 days	27.3	28.6	29.3	31.8	31.3	31
28 days	33	34	34	34	32.5	32

Figure 6. - Compressive strength test results for M25 grade concrete mix

Compressive strength test performed on the cubes at interval of 7 days, 14 days, and 28 days.

- Flexural strength test:
  Flexural strength test is performed to calculate the tensile strength of the concrete against bending moment
  The specimen prepared with plastic fiber mix is casted in structure with 150mm width, 150mm depth, and span of 700mm.

Figure 7. – Concrete specimen in a flexural strength testing machine

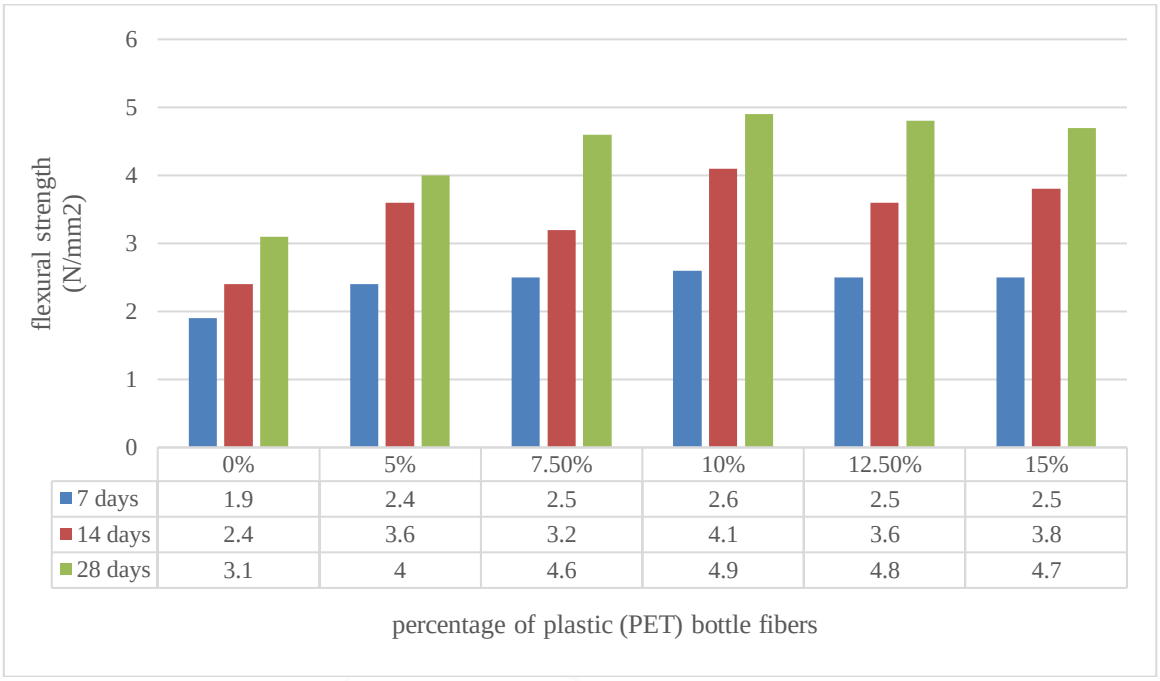


Figure 8. – Flexural strength test results for M20 grade concrete

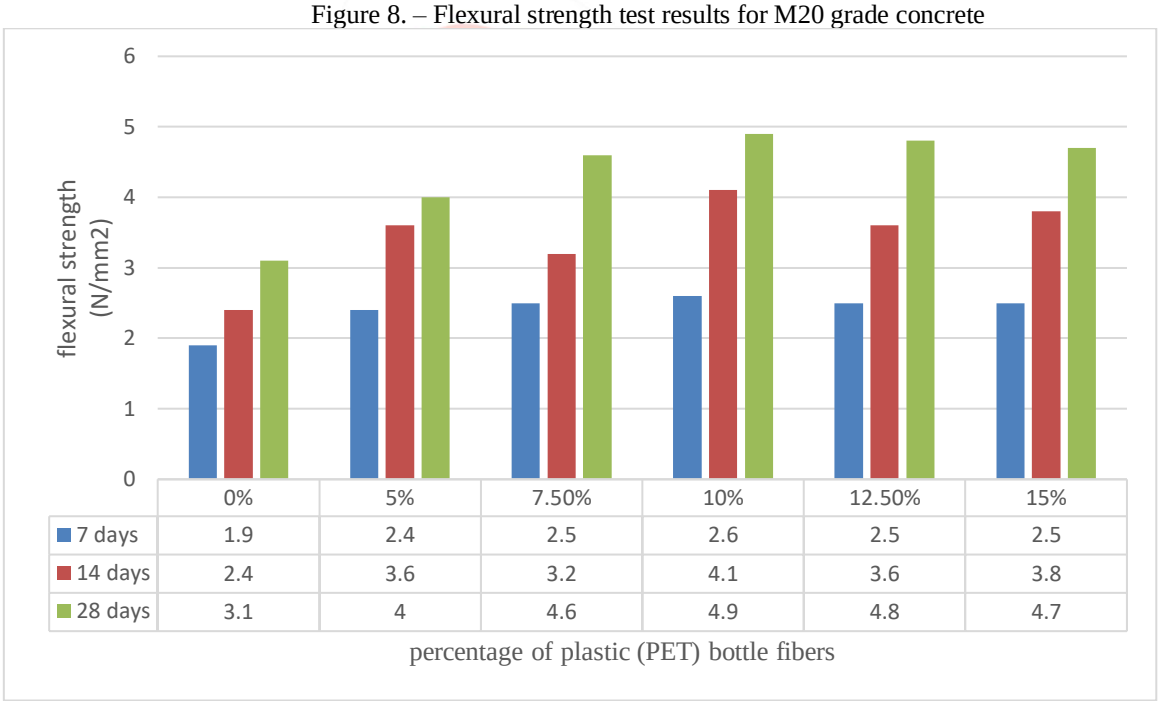


Figure 9. – Flexural strength test results for M25 grade concrete

Flexural strength test performed on the cubes at interval of 7 days, 14 days, and 28 days.

VI. CONCLUSION

- The plastic waste is difficult to dump, efficient solution is to reuse it.
- PET bottle waste can be reused without affecting the properties of the concrete.
- With increase in plastic percentage in concrete, there has been decrease in early strength, i.e. strength after 7 days and 14 days, but strength regained when tested again after 28 days.
- The compressive quality increases till 7.5% and 10% of substitution of fine aggregate by PET waste and it starts diminishing for 12.5% and 15% substitution. Thus supplanting of fine total with 7.5% to 10% substitution gives best results.
- Flexural quality gives best results upto 10% substitution of fine aggregate with PET waste.
- Specific gravity of PET plastic waste is less than the fine aggregate, hence unit weight of concrete reduces, thus it reduces the total weight of the structure.

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