Replacement of Coarse Aggregate with Plastic Fibers in Concrete Cube

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***Abstract*—The production of plastic is increasing at a faster rate. It is very difficult to dispose this plastic waste as it creates environmental pollution. Plastic bottles usually take thousands of years to degrade and produce toxic fumes when incinerated. As a matter of fact out of every 5 discarded waste bottles only 1 bottle is sent to the recycle bin. As a result huge mounds of PET bottles have been created on the earth's surface. For solving this problem, construction industry can take a step to utilize this plastic waste as a substitute for aggregates. This project is to examine the possibility of replacing coarse aggregate with plastic fibers in concrete cubes. In this work coarse aggregate is replaced partially with plastic fibers at different percentages (0%, 10%, 15%, 20%,) and optimum percentage has to be found. Several tests are done to determine the properties of concrete cube (150mm X 150mm X 150mm) containing plastic fibers and its suitability as a construction material. Also properties of concrete mix with plastic fibers was studied and compared with control mix with normal aggregates. The plastic fibers were used of aspect ratio 45 whose dimension is 90mm X 2mm.**

Keywords*— *Polyethyelene Terephthalene , plastic fibers, aspect ratio.

I. INTRODUCTION

Plastic is a non-biodegradable material which takes hundreds of years to degrade. The global production of the plastic is about 150 million tons every year. Earlier the recycling plastic bottles came into existence but it did not work efficiently. Plastic can be reduced, reused and recycled. Reducing the use of plastic is a difficult task nowadays due to the nature of living of humans. So the other ways to reduce environmental problems caused by plastic are by recycling or reusing the waste plastic. The recycling of the plastic can be done only 2-3 times as the plastic tends to lose its strength afterwards. In fact 70% percent of the plastic is left out as waste every year. This plastic waste leads to various problems such as landfill problem, and if it is disposed in water bodies, it causes water pollution leading to the death of various aquatic lives. Hence there's a need to find solution for this problem of plastic disposal. Plastic waste can also be used to produce new plastic based products after processing.

Many organizations along with government are working together to find solution for this and to build sustainable cities for the future. Replacing materials in concrete is one of the best solution for the disposal of plastic waste. It has economical advantage along with ecological advantages. Nowadays there is a huge scarcity of construction materials so waste materials are best alternative to be used in construction. It not only reduces the waste and pollution but also serves as an alternate material for aggregates in construction. Many tests have been performed to evaluate the properties of cement-composites containing plastic fibers as aggregates. This paper presents a review on the use of plastic fibers as coarse aggregate in concrete.

II. LITERATURE REVIEW

Ozbakkaloglu et al., 2017 performed various tests on mechanical properties of concrete containing waste plastic as a replacement of coarse aggregates under elevated and ambient conditions of temperature. The results showed that higher the replacement of (RPA's) in the specimen, lower is the corresponding workability of the mix. Liliana et al., 2013, found that as the size of the recycled plastic is increased, the Young's Modulus of the specimen decreased, and the compression strain increased. Jalali et al., 2011, studied the durability characteristics of polymeric waste particles in concrete. Albano et al.,2009, done more tests for w/c ratios (0.5 and 0.6), and it showed that the mixes with 10% replacement resulted to have the best mechanical properties, and the mixes with 20% replacement resulted to have the lower compressive strength. Semiha et al., 2009, carried out laboratory tests on the use of shredded waste PET bottles with GBFS and concluded that the mortar produced could be used as an earthquake resistant material. Its use proved productive for the environmental problems. Batayneh et al., 2007, evaluated the impact of waste plastic on the slump of specimen. Partial replacement of fine aggregates by waste plastic aggregates upto 20% replacement was checked. It showed that the slump was reduced to 25% compared to the control mix for a 20% replacement of fine aggregates with plastic content.

III. EXPERIMENTAL PROGRAM

3.1 *GENERAL*

Before casting the concrete specimens as per the mix design, the detailed laboratory tests were done to know the material properties. The ingredients of concrete (cement, fine aggregate, coarse aggregate) were evaluated as per IS specifications.

3.2 MATERIAL *PROPERTIES*

3.2.1. Cement

The ordinary Portland Cement (OPC) was used for this experiment. The cement was in dry state with fine grey powder. The cement used was from a single lot throughout the experiment. It was in fresh form without any lumps. The physical properties of the cement as determined from various tests done as per Indian Standard specifications are listed in Table 1.

Table 1. Material Properties

Materials	**Characteristics**	**Test** value
Cement	Specific gravity	2.67
Fine aggregates	Specific gravity	2.72
Coarse aggregates	Specific gravity	2.704

3.2.2. Fine Aggregates

Sieve analysis of fine aggregates were carried out in the laboratory.The sand was first sieved through 4.75 mm IS sieve to remove particles greater than 4.75 mm and then washed to remove the dust particles. It is then passed through 2.75 mm IS sieveand the retained particles are taken. The results of physical properties of sand are shown in Table 1.

3.2.3. Coarse aggregates

Coarse aggregates of 20mm size were used for the experiment. The aggregates were washed to remove dust and dirt particles and were air dried. The aggregates were tested and physical properties are listed in table 1.

3.2.4. PET Fibers

The waste plastic bottles were collected and washed. The bottle upper and lower parts were removed first and then it is cut across the height manually. Hereafter the bottle is cut into the required aspect ratio .The aspect ratio of 45 were prepared for the replacement of coarse aggregates in concrete mix. The dimensions of plastic fibers are 90mm X 2mm, as shown in figure1.

Fig.1. Plastic Fibers

3.2.5. Mixing and Casting

The grade of M20 concrete is designed in 1: 1.5: 3 ratios and the W/C ratio were 0.5. The concrete ingredients were mixed in dry state for obtaining a homogenous mixture. Hereafter plastic fibers were added in the mix. The coarse aggregates were partially replaced by the plastic fibers at 0%, 10%, 15%, 20%, of the weight of coarse aggregates. The required amount of water was added in the mix and cubes were filled with the mix and it is then vibrated on the vibrating table. Cubes of sizes 150mm X 150mm X 150mm were casted for evaluating the fresh and hardened properties of concrete. The mixing of concrete has been done at the room temperature. The quantity of design mix is as shown in table 2.

Table.2. Quantity of Mix Design

Sl.No.	**Replacement of C.A. with plastic**	**Cement (Kg)**	**F.A. (Kg)**	**C.A. (Kg)**	**Water Content**
1.	0%	5.65	10.93	13.65	190
2.	10%	5.65	10.93	12.3	190
3.	15%	5.65	10.93	11.6	190
4.	20%	5.65	10.93	10.96	190

4. PROPERTIES OF CONCRETE

i. Fresh concrete properties

a. Workability of concrete

Based on IS: 1199-1959 Slump testswere done to find the workability of concrete.

ii. Mechanical properties of the hardened concrete

a. Compressive strength of the hardened concrete

According to IS Specifications, the compressive strength test was done on concrete cubes of size 150mm X 150mm X 150mm on 7^{th} day and 28^{th} day.

IV. RESULTS AND DISCUSSIONS

a. Workability of concrete

The slump value is decreasing quickly with the increase in waste plastic ratio. The reduced slump values of waste plastic concrete mixes are due to lesser fluidity. The value of slump is shown in Table.3.

Table.3. Slump Values

% Replacement	**Slump value (mm)**
0%	120
10%	91
15%	64
20%	47

b. Compressive strength of hardened concrete

Cubical specimens of size 150mm X 150mm X 150mm were used to cast desired cubes for various curing ages. The obtained compressive strengths of 7^{th} day and 28^{th} day are shown in Table.4 and Table.5respectively.

Table.4. Compressive strength on 7^{th} day

% Replacement	**Compressive strength**
0%	17.2
10%	15.12
15%	14.06
20%	10.26

Table.5. Compressive strength on 28th day

% Replacement	Compressive strength
0%	28.2
10%	27.8
15%	27
20%	20.4

c. Optimum percentage of plastic fibers

The compressive strengths of concrete with 0% to 20% plastic fibers as replacement for coarse aggregates were determined. It was found that the optimum percentage of plastic fiber in concrete mix is 15%.

V. CONCLUSION

The strength of concrete cubes with plastic fibers as replacement for coarse aggregates tends to decrease with the addition of greater percentages of plastic fibers. It may be due to the decrease in the adhesive strength between the cement paste and plastic fibers. Moreover plastic is a hydrophobic material so it does not participate in the process of hydration.

As a result of the comparison between normal concrete cube and cube containing optimum percentage of plastic fibers, it showed better strength characteristics. Thus coarse aggregates in concrete can be partially replaced with plastic fibers. It not only helps to reduce waste plastic but also reduces the use of other materials in the construction process thereby reducing environmental problems.

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