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"A Study on Partial Replacement of Sand By Plastic Waste In Standard Concrete"

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Abstract — *At present, the construction cost as lack of sand is enhancing day by day. To counteract this problem, sand is partially replaced in the form of plastic wastes material. Plastic waste is recycled in the form of the production of new material that may be used as an optional component in Concrete & is one of the best ways to discard plastic waste. Also, these techniques proved to be highly cost-effective than ordinary methods. This dissertation aims to utilize plastic waste as an optional replacement (0%, 10%, 20%, 40% & 60 %) of innate river sand and test it for compressive strength, tensile strength, flexure strength, and sustainability.*

Keywords — *Recycle, plastic, Concrete, strength.*

I. INTRODUCTION

Concrete is a popularly used material in the world. More than 10 billion tonnes of Concrete are consumed annually. Depend on wide usage, and it is settled at the second position after water. Conventional Concrete, a dynamic material, is a blend of cement, sand, aggregate, and water. Aggregate content is the factor, which are direct and far-reaching effects on the property of Concrete. Unlike water and cement, which do not amalgam any particular characteristic except the quantity in which it is used, the aggregate component is infinitely variable in terms of shape and grading. Top-quality aggregate, both coarse and fine for Concrete, is of very extreme importance. Aggregates consume 60 to 80% of the total base volume of Concrete and affect the fresh and hardened particles of Concrete. Out of the total composition of Concrete, the fine aggregate consumes around 18 to 30% of the volume.

Drawbacks of Using Natural River Sand:

Natural Sand (NS) is deficient in many aspects when used directly for concrete production. Extraction of the sand from the river bed in excess quantity is hazardous to the environment. It is common to see that the bridges' well foundations are exposed considerably due to the excessive extraction of sand around the substructure, endangering the bridges' substructure. Excessive mining of the sand from river beds reduces the water head. This is due to the less percolation of rainwater in the ground. The absence of sand in river bed results in more water being evaporated due to

II. RECYCLED PLASTIC

Plastic is one of the materials showing immense potential in our daily lives as it possesses low density, high strength, user-friendly designs, fabrication capabilities, long life, lightweight, and low-cost characteristics are the factors behind such extraordinary growth. Although plastics have been used in very large and useful applications, it bestows to an ever-increasing amount in the solid waste stream. Polyethylene forms the largest fraction, followed by Polyethylene Concrete, the most widely used construction material in the world due to its high compressive strength, long service life, and low cost. The infield of concrete technology, India, and other nations now seek an alternative for conventional aggregate that may be recognized as Use plastic waste, for it might be realized as PET phase capacities. As per the estimates, India produces 500,000 tons of pet waste every year. Plastics constitute12.3% 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. At present, the total recycling capacity in India is around 145,000 TPA. Its Use in concrete mix will prove a better option for landfill that, being non-degradable, remain for long years and cause the problem before us. Unfortunately, the recycling rate of PET bottles is much less than the sales of virgin PET production for common uses. A possible application is to utilize waste PET pieces as a replacement of fine aggregates in Concrete. Plastics Packaging totals 42% of total consumption, and every year little of this is recycled.

III. LITERATURE REVIEW

Researchers are going in and around the world for the utilization of various wastes for different purposes. Some of the previous studies to replace fine aggregate in Concrete with various recycling plastic wastes are discussed.

Shyam, Drishya (2018) studied the partial replacement of M sand with High-Density Polyethylene powder. A comparison between conventional Concrete and Concrete with HDPE powder is carried out to study the strength and durability parameters. In this work, 5, 10, 15, and 20 percentage replacement of M sand with HDPE powder experiments. Based on the results and observations of the experimental work conducted, the following conclusions are drawn: plastic waste can be disposed of using them as a construction material in Concrete. Workability decreases with an increase in HDPE powder. Compressive strength, flexural strength, and split tensile strength of concrete decreases with an increase in HDPE powder. HDPE powder's optimum percentage of replacement in terms of workability and strength is obtained as 5%. Compressive strength increases up to 16.6% for 5% replacement of HDPE powder. Split tensile strength increases up to 22.815% for 5% replacement of HDPE powder. Flexural strength increases up to 46.34% for 5% replacement of HDPE powder.

Charudatta P. Thosar, Dr.M.Husain(2017) In their experimental investigation, replaced the natural river sand by using the plastic waste which is recycling from PET or PP waste. Partial replacement of sand by plastic waste material is done with M20 grade Concrete. The plastic waste was used to replace 20%, 40% & 60% of natural river sand in the concrete mixes and tested after 28 days for compressive strength, tensile strength, flexural strength, and modified Concrete density. The experiment revealed that the partial replacement of plastic waste material could be done to a limit of 20% to 40% for Concrete's satisfactory properties, which is an acceptable limit for the civil industry's constructional purpose.

M.Guendouz, Farid Debieb (2016) investigated the utilization of two types of waste plastic (Polyethylene Terephthalate (PET) and Low-Density Polyethylene (LDPE) used for bags manufacture) as plastic waste and fine aggregates (powder) in sand concrete. the same volume of plastic aggregates substituted various volume fractions of sand (10%, 20%, 30%, and 40%), and various amount of plastic waste (0.5%, 1%, 1.5%, and 2%) were introduced by volume in sand concrete mixes. The physical and mechanical properties of the composites produced were studied. The results showed that plastic waste as partial replacement of sand contributes to reducing the bulk density and decreasing the air content, causing an increase in compressive and flexural strength, especially for 10% and 20% of replacement. In addition, the reinforcement of the cementing matrix with plastic waste induced a clear improvement of the tensile strength. This study ensures that reusing waste plastic in sand concrete gives a positive approach to reducing materials' costs and solving environmental problems. (Ref.-5)

Saikia and Brito (2014) presented the effects of the size and shape of recycled polyethylene terephthalate (PET) aggregate on the fresh and hardened properties. Three types of PET aggregate, collected from a plastic recycling plant, two were shredded and separated fractions of similar types of PET bottles, and one was a heat-treated product of the same PET bottles with sieve size from 0.5-11.2mm. 5%, 10%, and 15% in volume of natural aggregate in the concrete mixes were replaced by an equal volume of three differently shaped and sized PET aggregates with deferent W/C ratios. Test results showed that the density of fresh Concrete decreased as the content of plastic aggregate increased. Differences in PET-aggregates' size and shape affect the slump of fresh concrete mixes, which ultimately change the mechanical behavior.

The study also observed a reduction in Concrete's compressive strength due to the addition of PET-aggregates to replace natural aggregates. For 5% replacement, the 28-day compressive is more than 75% of the compressive strength of reference concrete. For Concrete with 10% and 15% plastic aggregate are respectively 71% and 59%. According to the authors, natural aggregates and PET-aggregate cannot interact with cement paste, and therefore the interfacial transition zone in Concrete containing PET-aggregate is weaker than that in the reference concrete, which lowers the resulting compressive strength. (Ref.-8)

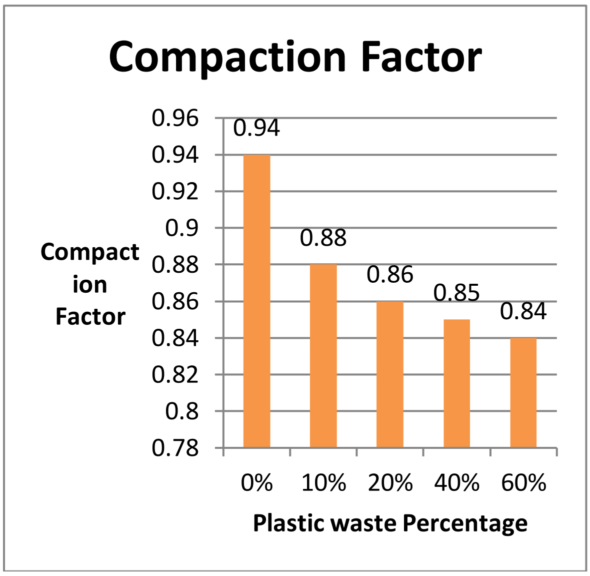
Rahmani et al. (2013) investigated the effects of replacing 5%, 10%, and 15% substitution of sand with PET processed particles. To determine the effect of sand replacement with PET on concrete flexural strength, some beam specimens with dimensions of 50 × 10 × 10 cm3were cast. (Ref.-6)

Hannawi et al. (2010) investigated the effect of using Non-biodegradable plastic aggregates made of polycarbonate (PC) and polyethylene terephthalate (PET) waste as partial replacement of natural aggregates in mortar. Various volume fractions of sand, 3%, 10%, 20%, and 50%, are replaced by the same plastic volume. The authors found a decrease in compressive strength when the plastic aggregates content increases. The drop in compressive strength seems to be not proportional to the volume fraction of sand replaced by plastic aggregates. a decrease of 9.8%, 30.5%, 47.1% and 69% for mixtures with, respectively, 3%, 10%, 20% and 50% of PET-aggregates, and of 6.8%, 27.2%, 46.1% and 63.9% for mixtures containing, respectively,3%, 10%, 20% and 50% of PC aggregates is observed.

According to the authors, the drop in compressive strengths due to plastic aggregates' addition can be attributed mainly to the poor bond between the matrix and plastic aggregates.

The study presented the variations in the flexural strength of different mixtures as a function of the

percentage of sand (in volume) replaced by the same volume of plastic 10 aggregates. By comparing the control mixture, no significant changes are observed for mixtures containing up to 10% of PET-aggregates and up to 20% of polycarbonate (PC) aggregates.
According to the authors, a decrease of 9.5% and 17.9% for mixtures with, respectively, 20% and 50% of PET-aggregates is observed. For mixtures with 50% of PC aggregates, a decrease of 32.8% is measured. The authors found that the



Calculated flexural toughness factors increase significantly with the increasing volume fraction of PET and PC aggregates. Thus, the addition of PC and PET plastic aggregates in cementations materials can give good energy-absorbing material, which is very interesting for several civil engineering applications like structures subjected to dynamic or impact.

IV. RESULT AND DISCUSSION

Workability of Concrete

The workability of concrete is an important property to determine before placing Concrete. Concrete with a high compaction factor is said to be more workable.

Table 5.1: Compaction Factor of Concrete W.R.T. Plastic waste Percentage

Plastic waste Percentage	Compaction Factor
0%	0.94
10%	0.88
20%	0.86
40%	0.85
60%	0.84

Table 1.1 shows values of compaction factor for the different values of plastic content in Concrete. Concrete without plastic has a high compaction factor, whereas Concrete with maximum plastic content showed the lowest compaction factor.

Compaction Factor of Concrete with plastic waste

The comparison of Compaction factor for various plastic content percentages. It is observed that as the polypropylene plastic content in concrete increases compaction factor of concrete decreases accordingly; hence the workability decreases. So Concrete with 0% plastic has high workability, and Concrete with 2.0% has the lowest workability.

Slump Test

Table No. 1.2 Slump for Control mix of M25 & M30 Grade

S. No.	Control Mix	Slump (mm)
1	M25	75

Table No. 1.3 Slump with Plastic waste

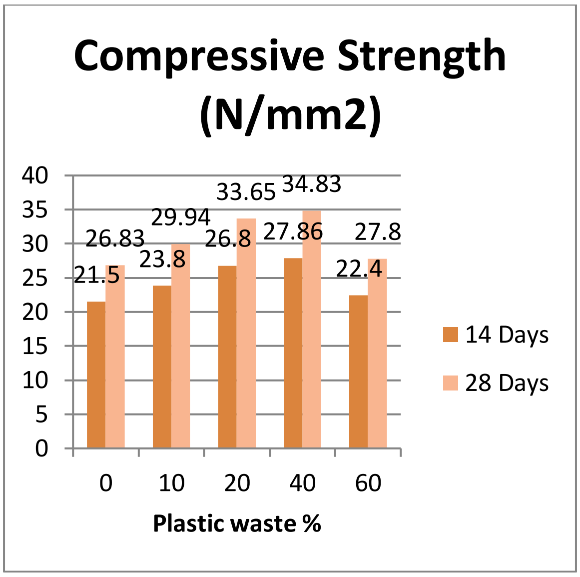
S. No.	Plastic waste %	Slump (mm)
		M25
1	0.0	70
2	10	68
3	20	64
4	40	61
5	60	59

Compressive Strength of Concrete

Compressive strength of Concrete is the utmost property of Concrete. Cubes of dimensions 150×150×150 mm were cast and testes for compressive strength on the compression testing machine.

Table 1.4 Compressive strength of M25 grade

Plastic waste %	Compressive Strength (N/mm2)	
	14 Days	28 Days
0.0	21.5	26.83
10	23.8	29.94
20	26.8	33.65
40	27.86	34.83
60	22.4	27.8



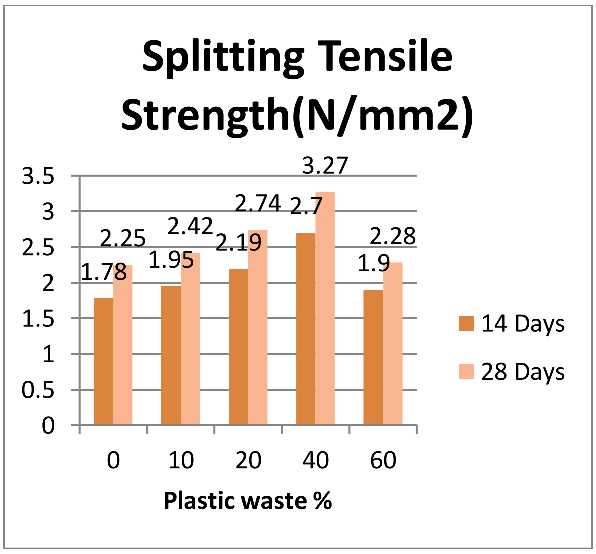
Comparative Compressive Strength of M25 Grade

Split Tensile Strength of Concrete

Concrete is weak in tension, so the testing of cylinder specimen for tensile strength is required. Cylinders of dimensions 150mm (dia.) and 300mm (length) were cast and tested for split tensile strength on the universal testing machine.

Table 1.5 Splitting Tensile Strength of M25 grade

Plastic waste %	Splitting Tensile Strength (N/mm2)	
	14 Days	28 Days
0.0	1.78	2.25
10	1.95	2.42
20	2.19	2.74
40	2.7	3.27
60	1.9	2.28



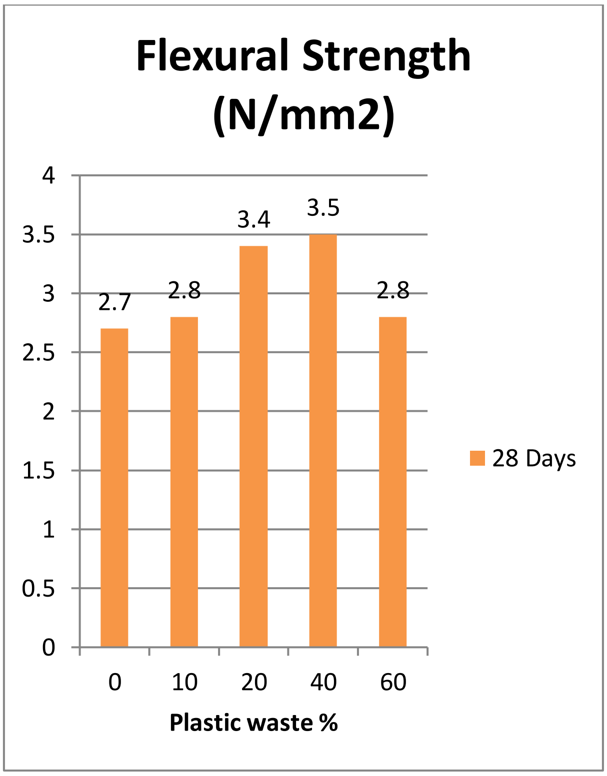
Comparative Splitting Tensile Strength of M25 Grade

Flexural Strength of Concrete

Flexural strength is one measure of the tensile strength of Concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending. For the flexural strength test, beams of dimensions 100×100×500 mm were cast and tested on the flexural testing machine.

Table 1.6Flexural Strength of M25 grade

Plastic waste %	Flexural Strength (N/mm2)	
	28 Days	Percentage Increased
0.0	2.7	-
10	2.8	11.53
20	3.4	26.92
40	3.5	30.77
60	2.8	3.84



Comparative Flexural Strength of M25 Grade

V. CONCLUSION

General Result Discussion

In this research, Experimental work was done.

- Accomplish Compressive strength test, split tensile test, and flexural strength on Concrete having different percentage (0%, 10%, 20%, 40%, and 60%) of plastic waste.

Results: In this experiment, Mix-Design of M-25 grade concrete; reference IS 10262: 2009, having water-cement ratio 0.45 is considered. Percentage of plastic aggregates (0%, 10%, 20%, 40% and 60%) is added in concrete. Specimens plastic aggregate Concrete was cast with great precision and was cured for 14 days and 28 days. During concreting/casting of cubes, compaction factor test and slump test on fresh Concrete was conducted for verification of workability with above percentage (%) addition of plastic waste, i.e. (0% to 60%). After completion of the maturity period of concrete Compressive strength test, split tensile test, and flexural strength test was conducted on all the specimens with respective date of casting. From the study, it was observed that compressive strength increased to increase the percentage (%) of plastic aggregate (0% to 40%) after 40% of plastic aggregate compressive strength decreases for both 14 days & 28 days cube strength. It was also observed that the optimum percentage increment in compressive strength of Concrete was 40% for 14 days and 28 days.

The optimum percentage increment in split tensile strength was 51.68 % for 14 days curing and 45.33% for 28 days at 40% plastic aggregate.

It was also noted that the flexural strength of concrete increases gradually with the addition of plastic aggregate, and minimum flexural strength was obtained at 0% (2.7 N/mm2). 3.5 N/mm2 optimum flexural strength was obtained with the addition of 40% plastic aggregate after 28 days of curing.

The study of strength and durability of Concrete made with using alternate material such as plastic aggregate in different percentages as part replacement of fine aggregate (sand) is concluded that up to 40 % of this material quantity can be used in concrete formation to achieve designed characteristic compressive strength in 28 days. The Use of alternate materials exceeds beyond 40 %, results in gaining strength below the specified, designed strength. However, The Concrete made of such combinations may use for the construction of mass concrete foundation works, embankment filling works, sub surfaces of roads, floorings, landfills with lean Concrete, and other concrete works where durability is of prime factor and strength is a secondary issue

6.3 Recommendations for Future Studies

Many studies were carried out on the utilization of plastic aggregate Concrete. Most of the studies are focused on the enhancement of the physical and mechanical properties of Concrete. For hardened concrete, the chemical attack is the main reason for the corrosion in Concrete, so plastic aggregate concrete is observed by experimental studies. After increasing its tensile strength, it can be used for dynamic structures also.

- After increasing the tensile and flexural strength of Concrete, it be can replace mechanically compacted Concrete.
- There is a huge scope in cost comparison of plastic aggregate Concrete with different additives as fly ash, furnace slag, etc.
- After increasing the strength of Concrete, it can also be used in heavy structures like bridges, dames, foundation work, etc.
- Similarly, after the strength of concrete increases, it can also be used for precast structures.
- Plastic aggregate concrete can also use in the rigid pavement for impact load resistance on expressways and highways, which can use for the landing of military tanks and aircraft landing.

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