Experimental Analysis of Concrete Prepared By Using Plastic Trash As Partial Replacement of Coarse Aggregate

Swapnil Tripathi[1], Hirendra Pratap Singh[2], Rakesh Sakale[3]
[2] Asst. Prof
[3] Prof
[1, 2] School of Research & Technology, People's University Bhopal (M.P.)

Abstract- *In this experimental study, plastic trash is used as a partial replacement for coarse aggregate in cement concrete mixture. Numerous attempts have been made to reduce the rising rate of plastic consumption. Despite the fact that plastic is a part of every aspect of our existence. Such solid waste disposal is loaded with financial difficulties and worries. Massive amounts of plastic are released into the environment every day, polluting it. Therefore, it is essential to use plastic as a replacement for engineering work. Today, one of the most important engineering materials available on the market is plastic. The use of waste plastic as a source of energy is a part of the solution to ecological and environmental problems. Consequently, the utilization of plastic waste, lower aggregate costs, and reinforced constructions. In this experimental research, we used crushed plastic bottles make up the plastic waste. In some instances, plastic trash—a non-biodegradable material—is utilised to replace coarse aggregate.*

Since it is not feasible to completely replace natural coarse aggregate with plastic waste, only partial replacement is examined in the current dissertation work. In this study, plastic waste is used to partially replace coarse aggregate. The coarse aggregate is replaced by plastic chips in the following four mix proportions: 0%, 10%, 15%, and 20%. Concrete's compressive and tensile strengths are assessed after 28 days of curing. In this laboratory experimental research, we used waste Polyethylene High-Density (PEHD) or High-Density Polyethylene (HDPE). The tests were carried out using M-25 mix and carried out in accordance with the recommended method and IS code regulations.

I. INTRODUCTION

A massive amount of trash is produced as a result of the world's expanding population. As a result, environmental issues, the security of natural resources, and waste material recycling are all getting a lot of attention. Thanks to developments in civil construction, a new waste material is now being used globally to address the challenge of disposing of enormous volumes of plastic garbage.

Nearly everything in contemporary society contains plastic in one form or another. In their daily activities, people will come into contact with plastic continually. Although it has long been believed that humans depend heavily on plastic, its production, use, and transportation have not been thoroughly studied. Around the world, there are numerous recycling facilities where a sizable proportion of plastic is recycled before being dumped in landfills. In this instance, using it or utilising it in concrete would be advantageous for the construction industry as opposed to continually recycling it. Given the aforementioned, recycling plastic waste would help to ease environmental worries.

As part of efforts to lessen the environmental impact of plastic rubbish, the use of plastic waste as an aggregate for concrete is being studied. These long-chain polymers frequently include hazardous substances, and since concrete structures have a very long service life, incorporating plastic in concrete mixes helps prevent plastic from coming into direct contact with the environment. The need for natural resources like concrete is also increasing.

In the meantime, growing demand for natural materials such as road paving or concrete formers may result in over-exploration of natural aggregates, harming the ecosystem and raising the possibility of landslides. Natural aggregate deposits would become less readily available with continued use, and quarries might be located further away from the construction site, raising the cost of the raw materials used to make concrete. After undergoing a certain process, plastic waste is routinely recycled into new products. However, because the recycling process yields lower-quality recycled plastic products, it becomes unprofitable and plastic makers opt to generate new plastic instead of recycling products.

Therefore, it is possible to recycle the unwanted plastic waste by using it as a synthetic aggregate. Plastic has been used by researchers from various different countries throughout the world. Plastic is commonly employed in its raw or recovered forms and can be used as aggregates or fibres in concrete, which is made up of waste.

To select the best plastics from the landfill's recovery, plastics were sorted. Approximately 10–12 mm in size, crushed, then washed to remove foreign objects. When it comes to concrete, plastics provide a lot of benefits: Due to its beneficial properties, such as amazing plasticity, the capacity to be tailored to fit certain technological demands, and a lower weight than competing materials, which lowers fuel consumption during transportation, plastic is becoming more and more common.

II. LITERATURE REVIEW

The work by Nehdi and Khan (2001) examines another technically and economically appealing option: the use of recycled tyre rubber in Portland cement concrete. Workable rubberized Portland cement (rubcrete) combinations may be generated, according to preliminary investigations, if adequate quantities of tyre rubber are utilised. Achievements during this area are examined during this paper, with special focus on engineering properties of rubcrete mixtures. These include workability, compressive strength, split tensile strength, flexural strength, elastic modular, Poissons ratio, toughness, impact resistance, sound and heat insulation, freezing and thawing resistance.

Rafat et al. (2008) presented a review of waste and recycled plastics and various waste management options. It also reviewed the published literature on the effect of recycled plastic on fresh and hardened properties of cement concrete. The effect of recycled and waste plastic on bulk density, air content, workability, compressive strength, splitting tensile strength, modulus of elasticity, impact resistance, permeability, and abrasion resistance properties are also discussed

Hannawi et al. (2010), compared the flexural strength of mortar specimens containing up to 10% PET aggregates and up to 20% PC aggregates to a control mix, found no significant differences in flexural strength. However, for mixtures containing 20% and 50% PET aggregates, respectively, a drop of 9.5 percent and 17.9 percent was observed. A reduction of32.8 percent was seen in mixtures containing 50 percent PC aggregates. The elastic nature of the plastic aggregate, and therefore its non-brittle features under loading, may have an influence on the measured flexural strength.

Kandasamy and Murugesan (2011) studied the impact of adding polythene fibres (domestic waste plastics) at a dosage of 0.5 percent by weight of cement in concrete. The properties of compressive and flexural strength were determined for M-25 mix. The addition of 0.5 percent polythene (household waste polythene bags) fibre to concrete boosts cube compressive strength by 0.68 percent in seven days, cylinder compressive strength by 3.84 percent in 28 days, and split tensile strength by 1.63 percent.

Lakshmi and Nagan (2011) used E-plastic waste as part of the coarse aggregate was studied. The trash E-plastic particles came from electrical and electronic equipment that was no longer in use. The compressive strength of concrete using varying quantities of E-waste (4%, 8%, 12%, 16%, 20%, 24% and 28%) as coarse aggregate in the concrete has been undertaken. The replacement of cement by fly ash (10% by weight) found to improve the properties of E- plastic waste concrete. Compressive strength, split tensile strength, flexural strength, sulphate and chloride attack were all investigated on E plastic concrete specimens. The E-plastic concrete demonstrated a substantial increase in compressive strength when compared to traditional concrete.

Saikia and Brito (2012) studied an overview of the use of plastic waste as aggregate in cement mortar and concrete manufacture. The types of plastic and techniques for preparing plastic aggregate were briefly reviewed in the first section, as were the procedures for evaluating aggregate and concrete qualities. The characteristics of plastic aggregates, and therefore the diverse fresh and hardened concrete properties of cement mortar and concrete in the presence of plastic aggregate, are examined in the following two sections.

The fourth section examines the practical consequences of using plastic waste in concrete manufacturing as well as future research requirements. Because the use of plastic aggregate can lower the density of the final concrete and cement mortar, multiple research have been conducted to make lightweight concrete using various types of plastic aggregate.

Afi et al. (2013), studied the use of waste plastic (polyethylene terephthalate (PET) in self- compacting mortar (SCM). The physical and mechanical properties of self-compacting mortars (SCMs) manufactured from plastic waste were investigated in an experiment. At certain doses, sand is replaced by plastic trash (0 percent , 10 percent , 20 percent , 30 percent and 50 percent by weight of the sand). The physical (bulk density, porosity, water absorption, and ultrasonic pulse velocity testing) and mechanical (bulk compressive and flexuralstrength) characteristics of SCMs were assessed, as well as a micro structural examination of the cementations matrix and plastic waste interface.

The measurements of physical and mechanical qualities reveal that mortars containing 50% plastic waste perform better than those containing other amounts of trash in terms of material density. The mechanical strength of the mortars is suitable for lightweight materials. According to the findings, a decrease of 15% and 33% for mortar containing 20–50% plastic waste was achieved.

The flexural and splitting tensile strengths of concrete using three types of recycled polyethylene terephthalate (PET) aggregate were examined by Saikia and Brito (2013). It was observed that the compressive strength of concrete containing all types of PET-aggregate behaves similar to the conventional concrete, though the inclusion of any type of PET- aggregate considerably decreases the compressive strength of concreteThe use of PET- aggregate enhances the toughness of the final concrete mix. This behaviour was influenced by the form of the PET-aggregate and was most pronounced in concrete containing coarse, flaky PET-aggregate. The splitting tensile and flexural strength characteristics are proportional to the loss in compressive strength of concrete containing plastic aggregates.

Balaji and Kumar (2014) studied M-25 mix was used in an experimental investigation, and tests were given according to the procedures indicated by relevant IS regulations. Because a complete replacement of natural coarse aggregate with plastic aggregate is not possible, partial replacements were investigated, including the use of hair as a fibre reinforcing material in concrete as a partial replacement for cement. The tests were carried out on concrete cubes containing various percentages of human hair, namely 0 percent, 0.5 percent,1.0 percent, 1.5 percent, 2.0 percent, and 3.0 percent by weight of cement, as well as a constant proportion of plastic aggregate of 20%.

Sabarinathan and Suresh (2016) discusses the usage of plastic fibres and M sand as concrete replacement materials. The coarse aggregate was replaced with plastic fibres and the M-sand was replaced with river sand to observe the behaviour of concrete changed with different quantities.

The fresh characteristics of concrete were investigated to ensure that the workability of the material was not harmed. The cubes, cylinders, and prisms were cast and tested of cement concrete with and without replacement materials, at the age of 28 days. The fresh concrete test shows that the amount of plastic fibre in the concrete increases, the workability of the concrete decreases. The plastic fibres with optimal volume content are frequently used to increase ductility in concrete. The toughness and impact load were also boosted to a higher level.

Thosar and Husain (2017) studied the industrial wastes made of polypropylene (PP) and polyethylene terephthalate (PET) as replacements to fine sand in concrete. For the concrete preparation, four replacement levels of aggregates were used: 20%, 40%, and 60% by volume of aggregates. According to the findings of this study, PP and PET may be utilised as a fine sand substitute in concrete containing 40% PP and PET by volume and produce good results. M-25 concrete has a nominal compressive strength of 20 N/mm2. When natural river sand is replaced with plastic waste material, the compressive strength of concrete is increased by 20% to 40%, up to a safe level.

Mahzuz and Tahsin (2019) used plastic trash as a partial replacement for coarse aggregate in concrete. For their research, they employed four volume-based mix proportions (1:1:1, 1:1.25:2.5, 1:1.5:3, and 1:2:4). The plastic was used to substitute stone in the following ratios: 0%, 25%, and 50%. The waste was made up of high-density polyethylene. After 28 days of curing, the compressive strength and unit weight were tested. The result revealed that compressive strength was up to 29.17%and 48.5% respectively.

Green concrete was created by Arivalagan (2020) using e-waste as a partial substitute for coarse aggregate at 10%, 20%, and 30%, respectively, with a water-cement ratio of 0.45. The recycle metallic portions in the e-waste were utilized, to increases the mechanical properties of green concrete. The green concrete specimens compared with conventional concrete, shows 20% increase in compressive strength.

III. METHODOLOGY ADOPTED

According to IS 10262-2019, the mix design for concrete of the M-25 grade required the following data:

1) The typical compressive strength at 28 days is 20 N/mm2.
2) The cement used complies with IS 1489: 1991 (part 1), and it is OPC.
3) Coarse Aggregate having a specific gravity of 2.825 and a free water absorption of 3.645 percent, measuring 12.5 to 20 mm in length and 2 to 8 mm in thickness.
4) Fine aggregate: River sand, which had a specific gravity of 2.68 and a free water absorption of 1.02 percent in accordance with IS 383:1970, was used as the fine aggregate.
5) High-density thermoplastic polyethylene (HDPE) plastic chips, 10–12 mm in diameter.3.5 kN/m3 unit weight, 5.91 modulus
6) Admixture: There is none.

In this study, hand mixing and the use of a concrete mixer with a mix ratio of 1:1.5:3 and a w/c ratio of 0.45 were both employed. In proportions of 0%, 10%, 15%, and 20% by weight of cement, the plastic chips, which serve as aggregates, are added to mixed concrete. The mould was constructed and thoroughly lubricated prior to mixing to enable quick removal of the hardened concrete. 150 mm cubes of 150 mm each and 150 mm wide are used to create the specimen. mm cylinders with a normal 150 x 150 x 150 mm mould size. When the mixture reached a plastic state, it was properly stirred with a shovel, and a slump test was carried out to ascertain the mix's W/C ratio. After then, it was added to a greased cast iron mould. The water cure approach was selected. The concrete cubes were given 24 hours to set before being demolded.In order to increase the concrete's strength, encourage hydration, avoid shrinkage, and absorb heat until the test's age, they were then placed in a curing tank.Curing times for the cubes and cylinders were seven, fourteen, and twenty-eight days, respectively. The cubes and cylinders were weighed before to testing, and the densities of the cubes at different times throughout testing were measured. The samples were removed from the curing tank, left outside in the fresh air for three hours, and then crushed.to determine the compressive strength, then tested in a compression testing machine (CTM).

IV. EXPERIMENTAL RESULTS

In the current work, plastic chips (about 10 to 12 mm) are used in place of some of the coarse aggregate in cement concrete of the M-20 grade. The impact of adding varying amounts of plastic chips to concrete: 0%, 10%, 15%, and 20%. It is determined how different percentages of plastic chips affect the workability, compressive strength, and flexural strength of concrete.

This chapter describes an experiment that substituted certain natural aggregates with waste plastic chips. The compressive strength test and the tensile strength test were both part of the experimental plan.Sand and cement are evaluated and verified in accordance with IS standards. Waste plastic chips were used in the concrete example to replace coarse aggregate by 10%, 15%, and 20%, respectively. Plastic chips size lesser than 12 mm used.

A compressive strength testing machine is used to evaluate the compressive strength of the the cubes containing 10%, 15%, and 20% waste plastic chips, followed by the compressive strength of the waste plastic tile.

A study was done to look into the mechanical properties of freshly made and partially replaced plastic chip concrete. A rate of loading controller was used with an 800 kN Universal Testing Machine (UTM) to measure the compressive strength of concrete, as shown in Fig- 1

Fig.-1 Compressive Strength setup

Fig.-2 Splitting tensile strength setup

V. RESULTS AND ANALYSIS

This study examined the fresh and mechanical properties of hardened concrete in order to better understand the behaviour of partially replaced plastic particles in the manufacturing of concrete. In the following section, the results of the compressive strength characteristics of cubes are also addressed, as are several graphs for comparing the compressive strength of various mix patterns.

5.1 DESIGN MIX RESULTS

This section discusses the experimental findings on various design mixes. The results include workability testing, compressive strength tests, and split tensile strength tests.

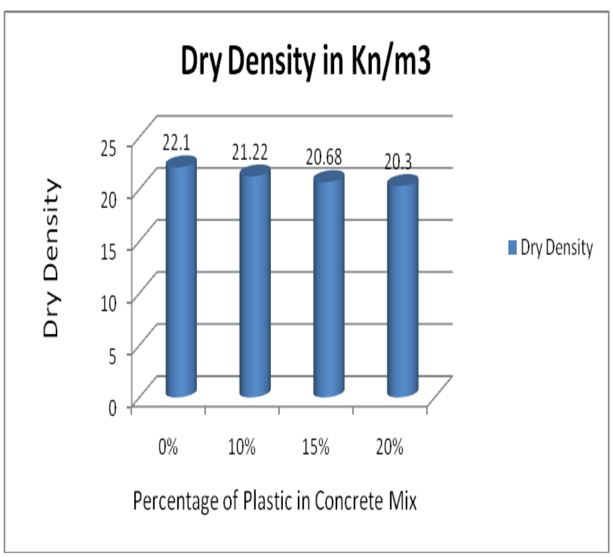
In this study, 36 cubes and 12 cylinders were cast and analysed over the span of seven, fourteen, and twenty-eight days. The comparison and findings are discussed in greater depth in the sections that follow.

5.1.1 Dry Density

In this experimental research study, the minimum dry density of concrete is 21.81 kN/m3 for a 20% replacement of coarse aggregate with plastic chips. There are four exams in total, one without and three with plastic chips. Table 5.7 displays the dry density values as well as the percentages of plastic. The dry density of concrete drops as the percentage of plastic chips increases, making it light weight.

Table-1 Dry density test results

TEST	PERCENTAGE OF PLASTIC	VALUE
Dry density (KN/m^3)	0%	22.10
	10%	21.22
	15%	20.68
	20%	20.30



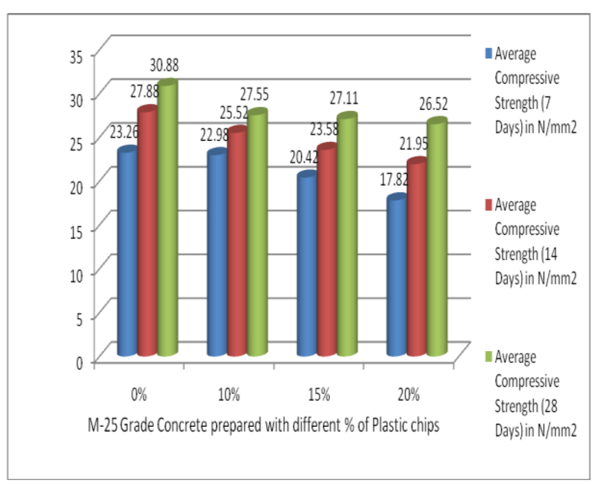
Graph-1 Dry density of concrete

5.2.2 M-25 Concrete Compressive Strength With And Without Plastic Chips

After 7 days, 14 days, and 28 days, the compressive strength of varied percentages of plasticchips added to concrete was determined using compressive strength testing equipment, as shown in figure 4.8.The following percentages of plastic chips were calculated: 5%, 10%, and 20%.Three cubes of each percentage of plastic chips were cast for precision, and the average of three test results was taken.The concrete cubes were cured at ambient temperature.The results of the compressive strength tests are shown in Table 5.9 and Fig. 4.8.With the inclusion of plastic chips, as shown in Figure 4.8.IS 10262:2019 is the reference code that was used.

Table- 2 7days, 14 days and 28 days compressive strength of M25 grade concrete with and without plastic chips.

S. No.	No. of days	% of Plastic chips	Average Compressive Strength in N/mm^2
1.	7 days		23.26
2.	14 days		27.88
3.	28 days	0%	30.88
4.	7 days		22.98
5.	14 days		25.52
6.	28 days	10%	27.55
7.	7 days		20.42
8.	14 days		23.58
9.	28 days	15%	27.11
10.	7 days		17.82
11.	14 days		21.95
12.	28 days	20%	26.52



Graph-2 Compressive strength of M-25 grade concrete with different % of plastic chips

VI. CONCLUSIONS AND FUTURE SCOPES

6.1 CONCLUSIONS

The current study can be used to draw the following conclusions:

1. As the percentage of waste plastic chips increases, the dry density of concrete decreases. Concrete has a minimum dry density of 21.81 kN/m3 for coarse aggregate replacement with plastic chips at a 20% substitution rate. The observed decrease in dry density is 8.14%. It is possible to substitute high-density polyethylene (HDPE) or polyethylene high-density (PEHD) waste plastic chips for some of the coarse aggregates in cement concrete mixtures. This further reduces the unit weight of the concrete. This is advantageous when lightweight non-bearing concrete is needed.
2. As the percentage of waste plastic chips increases, the workability of concrete containing plastic chips decreases. The size and shape of the plastic chips used may be the cause of the decrease in concrete's ability to be worked.
3. As the percentage of plastic chips increases, the compressive strength of concrete decreases. A 20% replacement level of natural aggregate was used to prepare the concrete.compared to normal mix (0% plastic chips), had compressive strength reductions of up to 13.1%.
4. 4. As the percentage of waste plastic chips increases, so does the tensile splitting strength.

Using more waste plastic chips to replace coarse aggregates will result in a lower strength of the final product, according to the findings of the current study.

6.2 FUTURE SCOPES

The following are the future scope of the present work:

1. The substitution of steel fibers for natural aggregates in cement concrete can be experimentally observed.
2. Alternative plastic materials to natural materials can be used in construction, such as LDPE and PP.
3. Rubber waste can also be used in cement concrete mixture for further testing.

REFERENCES

[1] Arivalagan S. (2020), Experimental Study on the Properties of Green Concrete by Replacement of E-Plastic Waste as Aggregate, Procedia Computer Science, 172, 985-990
[2] IS 10262:2019, Recommended Guidelines For Concrete Mix Design, Bureau of Indian Standard, New Delhi..
[3] IS 2386 (Part-1) 1963, Methods of test for aggregates for concrete, Bureau of Indian standard, New Delhi.
[4] IS 2386 (Part-3) 1963, Methods of test for aggregates for concrete, Bureau of Indian standard, New Delhi.
[5] IS 2386 (Part-4) 1963, Methods of test for aggregates for concrete, Bureau of Indian standard, New Delhi.
[6] IS 383-2016, Coarse and Fine aggregates for concrete-Specifications, Bureau of Indian Standard, New Delhi.
[7] IS 4031 (Part-1) 1988, Methods of physical tests for hydraulic cement, Bureau of Indian Standard, New Delhi.
[8] IS 4031 (Part-2) 1988, Methods of physical tests for hydraulic cement, Bureau of Indian Standard, New Delhi.
[9] IS 4031 (Part-3) 1988, Methods of physical tests for hydraulic cement, Bureau of Indian Standard, New Delhi.
[10] IS 4031 (Part-4) 1988, Methods of physical tests for hydraulic cement, Bureau of Indian Standard, New Delhi.
[11] IS 4031 (Part-5) 1988, Methods of physical tests for hydraulic cement, Bureau of Indian Standard, New Delhi.
[12] IS 4031 (Part-6) 1988, Methods of physical tests for hydraulic cement, Bureau of Indian Standard, New Delhi.
[13] IS 456-2000 Specifications For Plain And Reinforced Concrete.
[14] Kandasamy R. and Murugesan R. (2011), Fiber Reinforced Concrete (FRC) using domestic waste plastic as fibres, ARPN Journal of Engineering and Applied Sciences.
[15] Kinda Hannawi, Kamali-Bernard Siham, William Prince (2010), Physical and mechanical properties of mortars containing PET and PC waste aggregates, Waste Management 30(11), 2312-20.
[16] Lakshmi. R. S. and Nagan S (2011), Utilization of waste E plastic particles in cementations mixtures, Journal of Structural Engineering, 38 (1), 26-35.
[17] Mahzuz H. M. A., Tahsin Anika (2019) "Use of plastic as partial replacement of coarse aggregate for brick classifications, International Journal of Scientific and Technology Research 8(8), 883-886.
[18] Mohit Kumar, Anil Kumar Choudhary (2022) "A Review on Behaviour of Concrete by Partial Replacement of Coarse Aggregate with Waste Plastic" IJRASET.
[19] Nehdi, M. and Khan, A. (2001), Cementitious Composites Containing Recycled Tire Rubber: An Overview of Engineering Properties and Potential Applications, Cement, Concrete and Aggregates. CCAGDP, 23. http://dx.doi.org/10.1520/CCA10519J.
[20] Sabarinathan A., Suresh S. (2016) An investigation on fresh and hardened concrete on M30 concrete with plastic

fibres and M-sand", International Journal of Research and Innovation in Engineering Technology, 2(12), 64-70.

[21] Safi Brahim, Saidi Mohammed Aboutaleba Djamila, Maallemb Madani (2013), The use of plastic waste as fine aggregate in the self compacting mortars: Effect on physical and mechanical properties, Construction and Building Materials, 43, 436-442.

[22] Saikia N, Brito J. (2013), Waste polyethylene terephthalate as an aggregate in concrete. Material Research. 16(2).

[23] Saikia Nabajyoti and Brito Jorge (2012), Use of plastic waste as aggregate in cement mortar and concrete preparation : A review, Construction and Building Materials, 34, 385-401

[24] Siddique Rafat, Khatib Jamel and Kaur Inderpreet (2008), Use of recycled plastic in concrete." Journal of Waste Management, 28(10), 1835-1852.

[25] Thosar Charudatta P, Husain M. (2017), Reuse of Plastic Waste as Replacement of Sand in Concrete, International Journal of Innovative Research in Science, Engineering and Technology, 6(1), 789-794.