

**UTILIZATION OF RECYCLED PLASTIC WASTE AS PARTIAL REPLACEMENT
OF FINE AGGREGATE IN CONCRETE MIXES**

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Abstract

The increasing amount of plastic garbage has become a significant environmental issue, necessitating sustainable management techniques to lessen its negative effects. One practical strategy for resource reduction and environmental protection in the building sector is the use of recycled plastic waste in concrete. The use of recycled plastic trash as a partial substitute for fine aggregate in concrete mixes is examined in this study. The impact of several percentages of plastic trash (5%, 10%, 15%, and 20% by weight of fine aggregate) on the characteristics of both fresh and hardened concrete were assessed. Workability, density, flexural strength, compressive strength, and water absorption were among the important factors evaluated. The findings showed that adding plastic trash decreased density and workability, but that at greater replacement levels, compressive and flexural strength somewhat decreased. The mechanical performance, however, stayed within reasonable bounds for both structural and non-structural applications at lower replacement ratios (up to 10%). According to the study's findings, recovered plastic trash can be used to reduce environmental pollution and promote sustainable building practices by partially replacing fine aggregate in concrete.

Keywords

Recycled plastic waste, Fine aggregate replacement, Sustainable concrete, Mechanical properties, Waste management, Eco-friendly construction.

1.0. INTRODUCTION:

The main reasons concrete is the most used building material in the world are its affordability, durability, and adaptability. However, there has been substantial environmental damage and resource depletion as a result of the mining of natural aggregates for the making of concrete. At the same time, one of the most urgent environmental issues facing the world today is the exponential rise in plastic garbage. Global estimates indicate that millions of tons of plastic garbage are produced each year, much of it is not biodegradable and pollutes the air, water, and soil.[1]The use of recycled plastic trash in concrete as a partial substitute for natural fine aggregates is one possible strategy to address both problems. This method offers a sustainable substitute for disposing of plastic waste in addition to lessening reliance on natural sand. Incorporating plastic trash has been shown in recent years to enhance durability and chemical resistance, among other qualities, while it may marginally weaken mechanical strength at greater replacement levels. [2]Research has highlighted the two advantages of this strategy: sustainability in the building industry through material substitution and environmental protection through the management of plastic waste. Additionally, by encouraging resource efficiency and waste reduction, incorporating plastic trash in concrete is consistent with the ideas of sustainable development and the circular economy.[3]For this reason, the current study intends to examine the impact of using recycled plastic trash in place of some of the fine particles in concrete mixtures. With a focus on determining the ideal level of replacement appropriate for both structural and non-structural applications, the experimental program assesses the effects of various replacement levels (5%, 10%, 15%, and 20%) on workability, compressive strength, flexural strength, density, and water absorption.

2.0. LITERATURE REVIEW:

Over the past ten years, a lot of research has been done on the use of recovered plastic waste in concrete as a substitute for conventional methods of managing plastic waste and building sustainably. The impact of substituting plastic particles for tiny aggregates on the mechanical and durability characteristics of concrete has been the main focus of research. Research on the impact of using plastic waste to partially replace fine aggregates found that while larger percentages resulted in decreased strength and workability, low levels of plastic content (up to 10%) preserved compressive strength within allowable bounds. Nonetheless, the blends' decreased density suggested possible uses in lightweight building.[4] examined

different types of waste plastic in concrete, emphasizing that because plastics are not absorbent, durability performance improves even if mechanical strength tends to decline at greater replacement levels. They proposed the use of plastic-modified concrete in pavements and non-structural components. [5] Highlighted how recycling plastic trash into concrete offers long-term advantages. Although compressive strength slightly dropped, their experimental study showed that toughness and impact resistance were enhanced when up to 10% of sand was replaced with plastic trash. They came to the conclusion that concrete that has been treated with plastic helps to reduce waste and maximize resource efficiency. [6] Looked into the usage of waste polyethylene terephthalate (PET) in concrete further and found that adding it reduced density and increased resistance to the entry of chloride ions. According to their research, PET-based concrete may find use in situations where durability and light weight are more important than high compressive strength. [7]

3.0. METHODOLOGY:

The purpose of the experimental program was to assess the impact of using recycled plastic trash in concrete mixes as a partial substitute for fine aggregate. The following steps made up the methodology that was used: Cement: 43-grade Ordinary Portland Cement (OPC) was utilized. Fine Aggregate: Recycled plastic debris was used to partially replace natural river sand that met IS 383:1970 requirements. Coarse Aggregate: 20 mm nominally crushed granite was utilized. Recycled Plastic Waste: To replace fine aggregate, shredded plastic waste (mostly polyethylene and PET) with particle sizes ranging from 2 to 4 mm was used. Water: For mixing and curing, potable water devoid of contaminants was utilized. [8] Using IS 10262:2009 criteria, the concrete mix was proportioned to provide an M25 grade characteristic compressive strength. In addition to a control mix (0%), plastic trash was added at weight percentages of 5%, 10%, 15%, and 20% to partially replace fine aggregate. Prisms (100 × 100 × 500 mm) for flexural strength, cylinders (150 × 300 mm) for split tensile strength, and cubes (150 × 150 × 150 mm) for compressive strength were all used to prepare concrete specimens. The standard protocols for mixing, compaction, and curing were adhered to. Water was used to cure the specimens for 7, 14, and 28 days. [9] The slump cone test is used to measure workability. Compressive Strength: As per IS 516:1959, tests were conducted at 7, 14, and 28 days. At 28 days, flexural strength was measured utilizing a two-point loading technique. Density: Determined by dividing the mass of cube specimens by

their volume .By submerging oven-dried specimens in water and calculating the % weight gain, water absorption is assessed.[10]To find the ideal amount of plastic waste replacement that balanced sustainability advantages and mechanical performance, the findings were compared to the control mix.

4.0. RESULT AND DISCUSSION:

Table 1: Mix Proportions with Recycled Plastic Waste

% Replacement of Fine Aggregate by Plastic Waste	Cement (kg/m³)	Fine Aggregate (kg/m³)	Plastic Waste (kg/m³)	Coarse Aggregate (kg/m³)	Water (kg/m³)	Water-Cement Ratio
0% (Control)	400	650	0	1200	200	0.50
5%	400	617.5	32.5	1200	200	0.50
10%	400	585	65	1200	200	0.50
15%	400	552.5	97.5	1200	200	0.50
20%	400	520	130	1200	200	0.50

The mix proportions shown in Table 1 show how recycled plastic trash is systematically substituted for natural fine aggregate at different percentages (5–20%). While the cement, coarse aggregate, water content, and water-cement ratio were constant, the amount of natural sand fell in proportion to the rise in the percentage of plastic trash. This made it possible to accurately assess how replacing plastic would affect the characteristics of concrete without being influenced by other mix design factors. Because plastic particles are lighter and less angular than those of natural sand, their presence affected the fine aggregates' packing density. Lower density mixes were the outcome, which is in line with results from past research. Furthermore, plastic's hydrophobic surface decreases cement paste bonding. As a result, greater percentages of plastic substitute typically result in decreased strength and workability. [11]However, by minimizing the environmental effect of sand extraction and

preserving mechanical performance comparable to that of traditional concrete, controlled replacement levels of 5–10% achieve a balance. Significant strength and workability decreases are usually seen at 15–20% replacement, suggesting that they are not appropriate for structural applications but may be used for lightweight, non-structural applications such as partition walls or paving blocks. These findings are corroborated who found that using up to 10% plastic waste in place of some sand preserved concrete's mechanical strength and improved its sustainability profile by lowering the use of natural aggregates and the build up of plastic waste.

Table 2: Fresh and Hardened Properties of Concrete with Plastic Waste

Slump (mm)	Density (kg/m ³)	Water Absorption (%)	Observations
75	2400	1.8	Good workability, reference mix
68	2360	2.0	Slight reduction in slump and density
62	2325	2.3	Acceptable workability
55	2290	2.6	Noticeable reduction in density
48	2250	2.9	Lower workability, lightweight concrete

The findings in Table 2 demonstrate how adding recycled plastic debris to concrete affects both its fresh and hardened qualities. As plastic replacement increases, the slump values clearly demonstrate a declining tendency. Only 48 mm of droop was reported by the 20% replacement mix, compared to 75 mm by the control mix. The hydrophobic properties of plastic particles, which reject water and lessen the lubricating action inside the concrete mix, are responsible for this decrease in workability. Concrete's density also dropped as its plastic content increased, going from 2400 kg/m³ for the control mix to 2250 kg/m³ at 20% replacement. This makes sense because plastic has a significantly lower specific gravity than real sand, making the composite material lighter. When less dead load is desired in non-structural applications, such lightweight blends might be useful. At 20% replacement, the

water absorption values increased gradually from 1.8% in the control mix to 2.9%. This suggests that a more porous microstructure results from a higher plastic content, mainly because plastic and cement paste have a weaker link. Although the increase in water absorption is not significant, it does imply that, if not optimized, increased plastic replacement levels may have an impact on long-term durability.[12]According to the findings, recycled plastic trash can be used up to 10% of the time without seriously affecting its fresh and toughened qualities. Higher amounts, however, might be more appropriate for lightweight, non-structural components. These results are consistent found that while adding more plastic decreased workability and density, it helped create lightweight concrete that may have long-term advantages.

Table 3: Mechanical Properties of Concrete with Plastic Waste

Compressive Strength (MPa) – 28 Days	Flexural Strength (MPa) – 28 Days	Split Tensile Strength (MPa) – 28 Days
35.0	4.5	3.0
34.0	4.4	2.9
32.5	4.2	2.8
30.0	3.9	2.6
28.0	3.6	2.4

In comparison to the control mix, the mechanical properties of concrete show a progressive decrease in strength parameters as plastic waste replacement increases (Table 3). At the maximum replacement level, the compressive strength dropped from 35.0 MPa in the reference concrete to 28.0 MPa. The decrease in load transfer efficiency can be ascribed to the plastic particles' low stiffness and non-polar surface properties, which erode the interfacial transition zone (ITZ) between the plastic and cement paste.[13]Likewise, as the amount of plastic increased, the split tensile strength declined from 3.0 MPa to 2.4 MPa and

the flexural strength decreased from 4.5 MPa (control) to 3.6 MPa. The limited ability of plastic particles to connect within the cementitious matrix is shown by both strength reductions. The trend of reduction is somewhat gradual, though, indicating that small percentages of plastic incorporation might still be appropriate for lightweight components, paver blocks, and non-structural panels—applications where great strength is not essential. These results are in line with earlier studies that found that using plastic instead of concrete decreases its compressive, flexural, and tensile strength while increasing sustainability by using non-biodegradable waste. Therefore, regulating replacement levels can establish a compromise between acceptable structural performance and environmental benefits, even while mechanical strength diminishes with increasing plastic content.

5.0. CONCLUSION:

Its potential as a sustainable substitute material is demonstrated by the experimental study on the use of recycled plastic trash as a partial substitute for fine aggregate in concrete mixtures. The findings allow for the following deductions to be made: Because plastic particles are angular and hydrophobic, concrete's workability declined as its plastic concentration increased. Nonetheless, the workability stayed within reasonable bounds up to 10% replacement levels. Lighter mixtures were produced by reducing the density of concrete by increased plastic replacement. In instances where lightweight concrete is required, this feature may be useful. As the amount of plastic increased, the compressive, flexural, and split tensile strengths gradually decreased. However, for both structural and non-structural applications, the mechanical performance remained excellent and the drop was only slight at 5–10% replacement. Due to a weaker interaction between plastic and cement paste, water absorption somewhat increased as the amount of plastic rose. In order to balance sustainability and strength, it was determined that the ideal replacement level of recovered plastic waste as fine aggregate was between 5 and 10%. All things considered, the study shows that recycled plastic trash can be successfully added to concrete mixtures as a partial substitute for fine aggregate, supporting environmentally friendly building methods, lowering pollution levels, and conserving natural resources. Future studies can concentrate on long-term durability evaluations, combined use with other waste materials, and surface treatment of plastic particles.

6.0. ACKNOWLEDGEMENT:

I'm grateful to God and my mentor for providing me with this significant life chance.

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