IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

PARTIAL REPLACEMENT OF PLASTIC WASTE AS COARSE AGGREGATE IN CONCRETE ON STRENGTH CRITERIA OF M20

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Abstract: The increasing accumulation of plastic waste poses significant environmental challenges, prompting the need for innovative recycling methods. This study investigates the feasibility of using plastic waste as a partial replacement for coarse aggregate in M20 concrete, focusing on its impact on mechanical strength. Various percentages of plastic waste (0%, 5%, 10%, 15%, and 20%) were incorporated into the concrete mix design while maintaining the standard proportions for M20 grade concrete (1:1.5:3).
Compressive, split tensile, and flexural strength tests were conducted on concrete samples cured for 7, 14, and 28 days. The results indicated a gradual decline in compressive strength with increasing plastic replacement, with the maximum reduction observed at 20% replacement. However, the concrete with 10% plastic waste replacement demonstrated a balance between reduced strength loss and sustainability benefits, meeting acceptable performance criteria.

1. Introduction

The construction industry is a major consumer of natural resources, and concrete remains one of the most widely used materials globally. As urbanization and infrastructure development continue to rise, the demand for concrete is expected to grow. However, this growth comes with significant environmental implications, including the depletion of natural aggregates and the generation of substantial amounts of waste, particularly plastic waste. According to recent estimates, millions of tons of plastic waste are produced each year, a significant portion of which ends up in landfills and oceans, contributing to ecological degradation.

In response to these challenges, the concept of sustainability in construction has gained traction. One innovative approach is the partial replacement of traditional coarse aggregates with recycled materials, such as plastic waste. This method not only addresses the issue of plastic pollution but also reduces the reliance on natural aggregates, thereby conserving resources. Plastic waste, when processed properly, can be utilized as a lightweight aggregate, potentially enhancing specific properties of concrete while providing an avenue for waste management.

M20 grade concrete, characterized by a nominal compressive strength of 20 MPa, serves as a common benchmark for various construction applications, especially in residential buildings and non-load-bearing structures. The incorporation of plastic waste in M20 concrete presents an opportunity to explore the effects of varying replacement percentages on its mechanical properties, including compressive strength, tensile strength, and flexural strength. Understanding how these properties are influenced by plastic waste content is crucial for establishing guidelines for safe and effective use in construction.

This study aims to investigate the implications of replacing coarse aggregate with plastic waste in M20 concrete, focusing on the strength criteria. By examining various replacement levels (0%, 5%, 10%, 15%, and 20%), the research will provide valuable insights into the performance characteristics of plastic-infused concrete. The findings will not only contribute to the body of knowledge regarding sustainable construction practices but also highlight the potential for innovative solutions in mitigating the plastic waste crisis.

Ultimately, this research seeks to demonstrate that the integration of plastic waste as a partial replacement for coarse aggregate can lead to more sustainable concrete production without significantly compromising structural integrity. Through systematic testing and analysis, the study aims to provide a pathway for the construction industry to embrace circular economy principles, thereby fostering environmental responsibility and resource efficiency.

2. Materials and Methods.

Cement, aggregate, and plastic properties are determined using a standard IS procedures. In this study a cubes (150×150×150)mm were casted. Concrete mix was Prepared as per M20 design mix. Cubes specimens were casted for testing compressive strength at 7 ,14,28 Days to obtain the optimum percentage of the plastic aggregate. All the samples were compacted using vibrating table. Moulded samples were kept at standard temperature of 27° ±1° C for 24 hours after casting before being demoulded and placed in the curing tank up to testing period. A day before testing they were taken out and put at room temperature. The test result are the average results obtained on three identical specimens. The complete procedure of this study is drawn in Figure . An immediate indicator of the compressive strength of coarse aggregate plastic has been determined using a rebound hammer test. In general, the rebound number increases as the strength of the concrete increases, and it is controlled by a wide range of elements such as the cement type used, aggregates, the concrete's surface condition, its moisture content, and so on.

Material used

- cement opc 43 grade
- fine aggregates
- course aggregates
- plastic course aggregates

3. Results and Discussion

3.1 Workability

The workability of fresh concrete was evaluated using the slump cone test. The observations indicated that the slump value gradually decreased as the proportion of E-waste plastic increased in the concrete mix. The conventional concrete mix without E-waste showed the maximum slump value, reflecting higher workability, whereas mixes containing up to 20% E-waste plastic demonstrated a noticeable decline in slump.

The decrease in workability can be explained by the smooth and water-resistant nature of E-waste plastic particles. These particles reduce the bonding efficiency between the cement paste and aggregates, leading to lower cohesion within the mix. Despite this reduction, concrete mixes containing up to 5% E-waste plastic still maintained sufficient workability for standard construction applications.

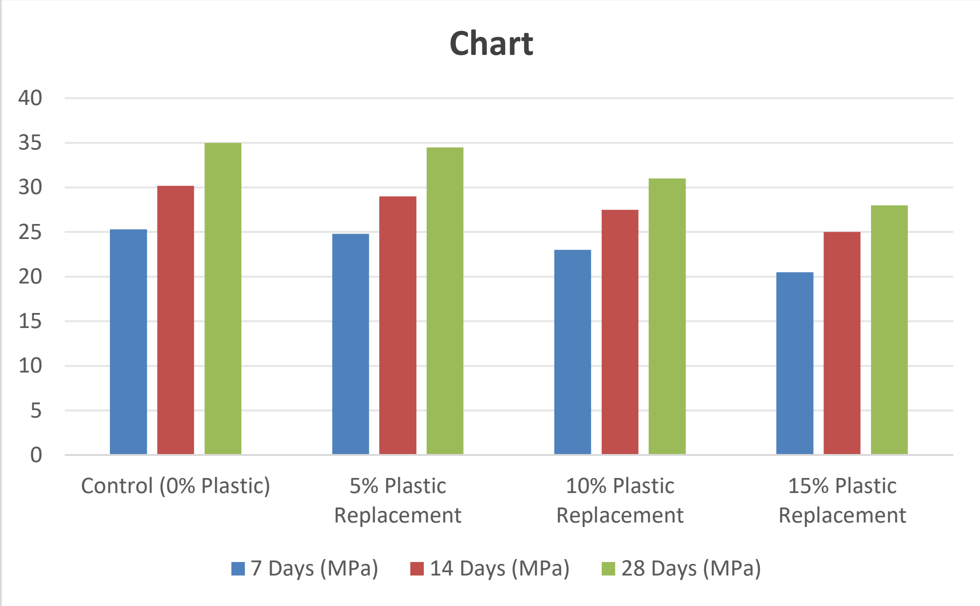
3.2 Compressive Strength Results

The results show a clear trend where the compressive strength of the control mix (0% plastic) is consistently higher than that of mixes containing plastic aggregates. While the strength at 7 days shows only a slight decrease with up to 10% plastic, a more significant decline is observed at 15% and 20% replacements.

The compressive strength of the concrete mixes was evaluated at three different curing ages: 7 days, 14 days, and 28 days. The results are presented in both tabular and graphical formats for clarity.

Table 3.2.1: Compressive Strength Trends at Different Ages

Mix Design	7 Days (MPa)	14 Days (MPa)	28 Days (MPa)
Control (0% Plastic)	25.3	30.2	35
5% Plastic Replacement	24.8	29	34.5
10% Plastic Replacement	23	27.5	31
15% Plastic Replacement	20.5	25	28
20% Plastic Replacement	18	23	26.5

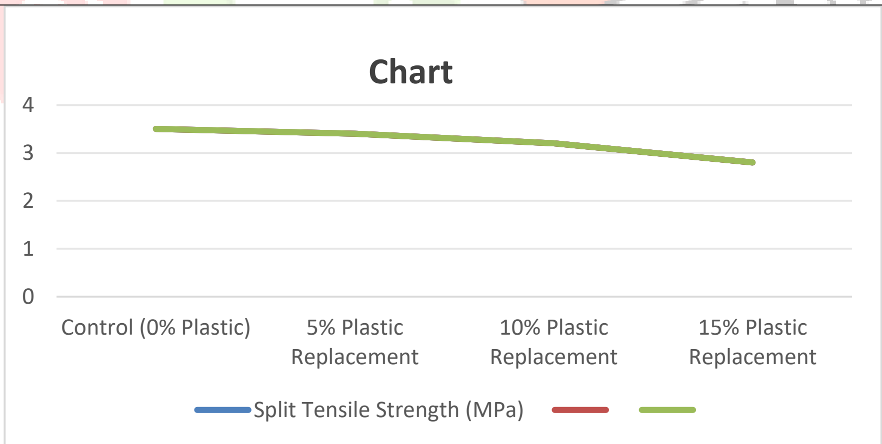


3.3 Split Tensile Strength Results

The split tensile strength of the concrete samples was assessed after 28 days of curing. The results are summarized in the
table below, which shows the tensile strength values for each mix design.

Table 3.3.1: Split Tensile Strength of Concrete Mixes

Mix Design	Split Tensile Strength (MPa)
Control (0% Plastic)	3.5
5% Plastic Replacement	3.4
10% Plastic Replacement	3.2
15% Plastic Replacement	2.8
20% Plastic Replacement	2.5

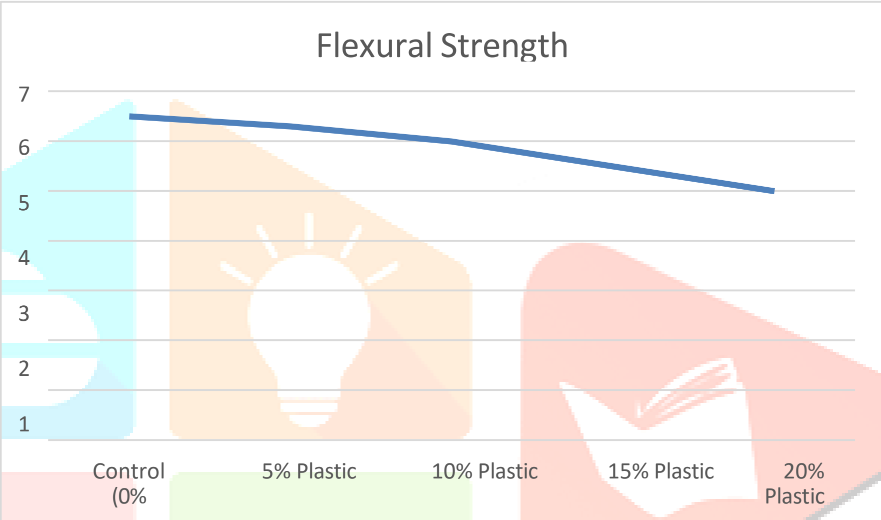


3.4 Flexural Strength Results

Flexural strength tests were also performed on the concrete samples after 28 days. Certainly! Here's a detailed section on Flexural Strength Results, focusing on the discussion of findings in relation to previous studies.
The flexural strength of the concrete mixes was tested after 28 days of curing. The results are summarized in the table below, which presents the flexural strength values for each mix design.

Table 3.4.1: Flexural Strength of Concrete Mixes

Mix Design	Flexural Strength (MPa)
Control (0% Plastic)	6.5
5% Plastic Replacement	6.3
10% Plastic Replacement	6
15% Plastic Replacement	5.5
20% Plastic Replacement	5



4 .Conclusions

The experimental analysis led to the following conclusions:

1.Increasing the proportion of E-waste plastic in concrete negatively affected both the workability and strength properties of the mix.

2.The concrete mix containing 5% E-waste plastic demonstrated results that were relatively similar to standard M20 concrete in terms of mechanical performance.

3.Concrete specimens with 10% and 15% replacement levels showed considerable loss in strength, mainly due to weaker adhesion within the matrix and decreased compactness.

4.Among the tested mixes, 5% replacement of conventional material with E-waste plastic was identified as the optimum percentage for achieving acceptable strength along with improved sustainability benefits.

5.The incorporation of E-waste plastic in concrete supports eco-friendly construction by reducing waste accumulation and lowering the demand for natural aggregate materials.

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