STM JOURNALS

Journal of
Structural Engineering and Management

ISSN: 2393-8773
Volume 11, Issue 3, 2024
September—December
DOI (Journal): 10.37591/JoSEM

https://journals.stmjournals.com/josem

Research JoSEM

Evaluating the Structural Performance of Concrete with Partial Replacement of Fine Aggregate by Plastic Waste

Arpit Kushwaha[1,*], Harsh Rathore[2]

Abstract

This work evaluates the performance of concrete incorporating plastic waste as a partial replacement for fine aggregate, at replacement levels of 0%, 5%, 10%, 15%, and 20%. Various tests were conducted on fresh and hardened concrete to assess workability, strength, and durability. The slump cone and compaction factor tests were used to measure workability, yielding a slump range between 25–30 mm and a compaction factor of 0.98, indicating medium workability. Compressive strength tests revealed that concrete with 5% plastic replacement achieved near-optimal strength, comparable to conventional concrete, with a 28-day compressive strength of 30.01 N/mm². Similarly, the highest split tensile and flexural strengths were observed at 5% plastic replacement, beyond which strength values decreased as plastic content increased. The findings indicate that plastic waste can enhance certain mechanical properties when used at low replacement levels, particularly 5%, and offer a sustainable approach to utilizing plastic waste in concrete. This study underscores the potential of plastic-enhanced concrete as a viable alternative in construction, contributing to sustainable waste management practices.

Keywords: Concrete, plastic waste, fine aggregate replacement, compressive strength, tensile strength, flexural strength, workability, sustainable construction

INTRODUCTION

The increasing demand for construction materials, particularly fine aggregates like river sand, poses environmental and ecological challenges. Simultaneously, the accumulation of plastic waste has become a critical environmental issue worldwide. Innovative approaches in sustainable construction aim to address both concerns by incorporating plastic waste into concrete, reducing the reliance on natural aggregates while managing waste effectively. By partially replacing fine aggregates with plastic waste, this study explores an eco-friendly method to produce concrete, assessing its workability, compressive strength, split tensile strength, and flexural strength. The findings contribute to sustainable construction practices and provide insights into the feasibility of plastic waste as a beneficial additive in concrete.

***Author for Correspondence**
Arpit Kushwaha
E-mail: 365arpitkushwaha@gmail.com

[1]Research Scholar, Department of Civil Engineering, Sanjeev Agarwal Global Educational University, Bhopal, Madhya Pradesh, India
[2]Associate Professor, Department of Civil Engineering, Sanjeev Agarwal Global Educational University, Bhopal, Madhya Pradesh, India

Received Date: November 22, 2024
Accepted Date: December 18, 2024
Published Date: December 21, 2024

Citation: Arpit Kushwaha, Harsh Rathore. Evaluating the Structural Performance of Concrete with Partial Replacement of Fine Aggregate by Plastic Waste. Journal of Structural Engineering and Management. 2024; 11(3): 69–75p.

Objectives

The primary objective of this study is to assess the feasibility of using plastic waste as a partial replacement for fine aggregate in concrete, thereby promoting sustainable construction practices and reducing environmental impact. To achieve this, the study first evaluates the workability of concrete mixes with varying percentages of plastic waste

© STM Journals 2024. All Rights Reserved

(0%, 5%, 10%, 15%, and 20%) through slump cone and compaction factor tests, which provide insights into the ease of handling and uniformity of the concrete. The study then focuses on the mechanical performance of these concrete mixes by examining compressive strength at intervals of 7, 14, and 28 days, enabling an understanding of the load-bearing capacity with different plastic replacement levels. Furthermore, the study investigates the tensile properties of the concrete through split tensile tests, providing a perspective on its resistance to tensile stresses, while flexural strength tests measure the bending resistance of concrete with plastic inclusions. Ultimately, this research aims to validate the potential of plastic waste as an eco-friendly and effective alternative to natural aggregates in concrete, contributing valuable insights into waste management in construction materials and expanding the options for sustainable building practices.

MATERIAL

Cement

Ordinary Portland cement of 53grade [IS: 12269 – 1987] specifications for 53 gradeOPC is used.

Plastic Waste

Waste plastic bottles like polypropylene are used in this experimental work.

Fine Aggregate

River sand belongs to zone II.

Coarse Aggregate: Coarse Aggregate of specific gravity 3.1 and impact value of 30% were utilized.

Superplasticizer

Polycarboxylate ether-based superplasticizers is used in this work

Mix Proportion

Designed a mix for M25 grade concrete for the following data

a. *Grade designation:* M25
b. *Type of cement:* OPC 53 grade
c. *Cement content:* 300 kg/m3
d. *Water cement ratio:* 0.40
e. *Method of Placing:* Manual
f. *Degree of supervision:* good
g. *Type of aggregate:* fine

RESULTS

Slump Cone Test

These tests measures the consistency of fresh concrete and also check the workability of the fresh concrete. Slump value for cement mixed concrete is 83 mm and mixture mixed concrete is 78 mm. Hence it is good workable condition for beams and columns.

Table 1. Slump Value.

Mix	w/c ratio	Slump (mm)
0%	0.48	25
5%	0.48	25
10%	0.48	26
15%	0.48	28
20%	0.48	30

© STM Journals 2024. All Rights Reserved

Inference: The concrete slump test measures the consistency of fresh concrete before it sets. It is performed to check the workability of freshly made concrete, and thereforethe ease with which concrete flows. It can also be used as an indicator of an improperlymixed batch.

Compaction Factor Test

Compacting factor of fresh concrete is done to determine the workability of fresh concrete by compacting factor test as per IS: 1199 – 1959.Compaction factor value is 0.98. The degree of workability of fresh concrete is medium

Compressive Strength

Inference: Compressive strength can be defined as the capacity of concrete to withstandloads before failure. Of the many tests applied to the concrete, the compressive strengthtest is the most important, as it gives an idea about the characteristics of the concrete. The compressive strength of concrete cubes were tested of size 150 mmx150 mmx150 mm for different proportions of replacement. And at the end of tests the results were compared with conventional concrete to check the strength obtained. The most feasible results are visible with only 5% of Plastic waste as partial replacement of fine aggregate when compared to other percentages.

Table 2. Compressive Strength of Concrete (N/mm^2).

Compressive Strength (N/mm^2)			
Mix	**7 days**	**14 days**	**28 days**
0%	18.35	25.55	30.09
5%	18.21	25.33	30.01
10%	18.21	25.16	29.76
15%	17.07	24.74	29.15
20%	17.01	24.62	28.99

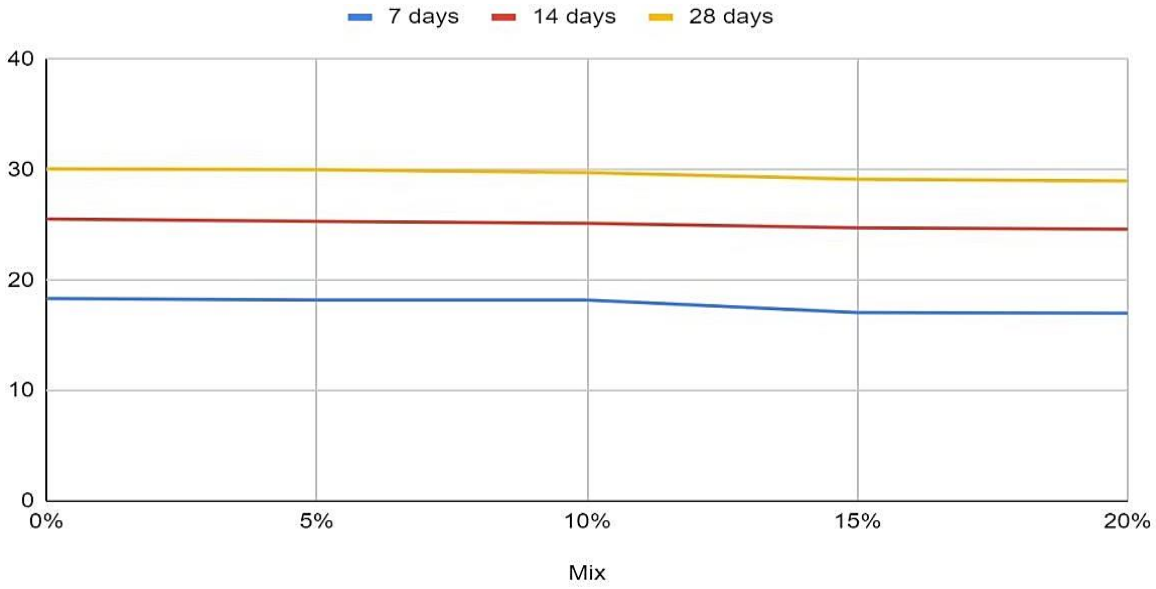

Figure 1. Compressive Strength of Concrete.

Split Tensile Strength Test

Inference: The split tensile test is conducted to find the strength of concrete in tension.For the testing of concrete, samples of different proportions are casted of 10cm in diameter and 20 cm in length of a cylinder. The splitting tensile strength test consists of applying a diametric compressive load along the entire length until failure occurs. This loading induces tensile stresses on the plane containing the applied load and compressive stresses in the area around the applied load. Maximum strength was

© STM Journals 2024. All Rights Reserved

attained with 5% plastic waste and reduces with increase in percentage of plastic.

Table 3. Split Tensile Strength Test in N/mm^2

Split Tensile Strength (N/mm^2)			
Mix	**7 days**	**14 days**	**28 days**
0%	1.63	2.17	3.34
5%	1.54	2.09	3.22
10%	1.16	1.81	3.19
15%	1.09	1.65	3.08
20%	1.02	1.51	2.91

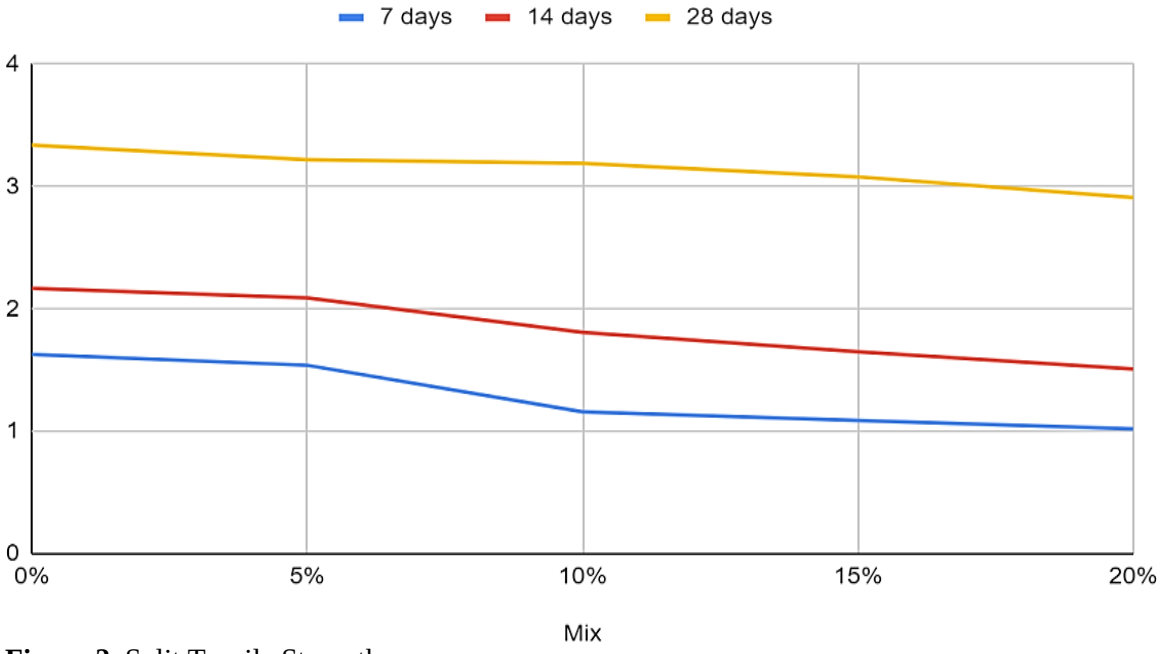

Figure 2. Split Tensile Strength.

Flexural Strength Test

Inference: Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced con- crete beam or slab to resist failure in bending. It is measured by loading 6 x 6-inch (150 x 150-mm) con- crete beams with a span length at least three times the depth. The maximum strength was achieved with 5% mixture whereas the strength reduces with increase in percentage of plastic

Table 4. Flexural Strength Test (N/mm^2).

Flexural Strength (N/mm^2)			
Mix	***7 days***	***14 days***	***28 days***
0%	0.146	0.235	0.279
5%	0.141	0.229	0.271
10%	0.131	0.225	0.266
15%	0.129	0.222	0.261
20%	0.121	0.218	0.255

© STM Journals 2024. All Rights Reserved

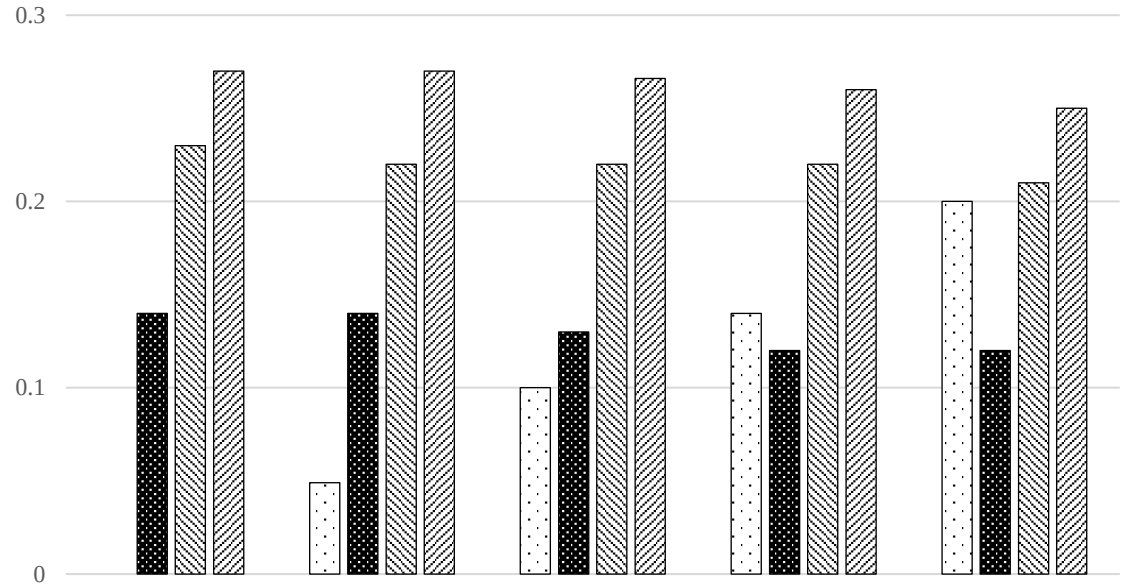

Figure 3. Flexural Strength Test in N/mm^2

CONCLUSIONS

Slump Cone Test: These tests measure the consistency of fresh concrete and also check the workability of the fresh concrete. Slump value for cement mixed concrete is 83 mm and mixture mixed concrete is 78 mm. Hence it is in good workable condition for beams and columns.

Compaction Factor Test: Compacting factor of fresh concrete is done to determine the workability of fresh concrete by compacting factor test as per IS: 1199 – 1959.Compaction factor value is 0.98.The degree of workability of fresh concrete was medium.

Compressive Strength: Compressive strength can be defined as the capacity of concrete to withstand loads. Before failure. Of the many tests applied to the concrete, the compressive strength test is the most important, as it gives an idea about the characteristics of concrete. The compressive strength of concrete cubes was tested of size 150 mmx150 mmx 150 mm for different proportions of replacement. And at the end of tests the results were compared with conventional concrete to check the strength obtained. The most feasible results are visible with only 5% of Plastic waste as partial replacement of fine aggregate when compared to other percentages.

Split Tensile Strength: The split tensile test is conducted to find the strength of concrete in tension. For the testing of concrete, samples of different proportions are casted of 10cm in diameter and 20 cm in length of a cylinder. The splitting tensile strength test consists of applying a diametric compressive load along the entire length until failure occurs. This loading induces tensile stresses on the plane containing the applied load and compressive stresses in the area around the applied load. Maximum strength was attained with 5% plastic waste and reduced with an increase in percentage of plastic.

Flexural Strength: 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. It is measured by loading 6 × 6-inch (150 x 150-mm) concrete beams with a span length at least three times the depth. The maximum strength was achieved with 5% mixture whereas the strength reduces with increase in percentage of plastic.

REFERENCES

1. Plastic Mix Concrete with Plasticizer], International Scholarly Research Network ISRN Civil Engineering Volume 2012, Article ID 469272, 5 pages.
2. Uma Shankar Yaligar, Mahesh Mahashetty, Md. Sarfaraz and Md. Aslam,[Study on Partial

© STM Journals 2024. All Rights Reserved

Replacement of Cement by Waste Plastic in Concrete,Iconic Research And Engineering Journals, AUG 2018 | IRE Journals | Volume2 Issue 2 | ISSN: 2456–8880.
3. Daniel Yaw Osei, [Experimental Investigation On Recycled Plastics As Aggregate In Concrete], International Journal of Structure and Civil Engineering, Vol. 3, No. 2, May 2014.
4. L.Ashwini and D.Jayaseelan, [Reuse Of Plastic Waste As A Replacement Of Sand In Concrete], International Journal of Advanced Research in Basic Engineering Sciences and Technology (IJARBEST), Vol.5, Issue.7, July 2019.
5. Kiran Tota-Maharaj, Blessing Oluwaseun Adeleke and Ghassan Nounu, [Effects of waste plastics as partial fine-aggregate replacement for reinforced low-carbon concrete pavements], International Journal of Sustainable Engineering, 2022, VOL. 15, NO. 1, 194–209.
6. K. Sai Gopi, Dr. T. Srinivas and S. P. Raju V, [Feasibility Study of Recycled Plastic Waste as Fine Aggregate in Concrete], E3S Web of Conferences 184, 01084 (2020).
7. Kawa A. Ahmed and Kamil. M. Yousif, [An investigation of the use of plastic waste as aggregate in concrete], Journal of Geoinformatics and EnvironmentalResearch Vol. 03, No. 02, pp. 46 –57 (2022).
8. D. RamaDevi, P. Vinodh Kumar and R. Vinodh Kumar, [Characteristics StudyOf Concrete Using Plastic Waste], International Journal of Engineering AppliedSciences and Technology, 2020 Vol. 4, Issue 12, ISSN No. 2455-2143.
9. Anita Intan Nura Diana, Subaidillah Fansuri and Akhmad Feri Fatoni, [An Experimental Study of Plastic Waste as Fine Aggregate Substitute for Environmentally Friendly Concrete], Advances In Technology Innovation, vol.6, no. 3, 2021, pp. 179–190.
10. Wegdan W. El-Nadoury, [Chemically Treated Plastic replacing fine aggregate in structural concrete], Frontiers in Materials, 22 July 2022.
11. Hargovind Shukla, Dr. Bharat Nagar and Nandeshwar Lata, [A Study on PartialReplacement of Sand By Plastic Waste In Standard Concrete], SSRG International Journal of Civil Engineering Volume 6 Issue 7, 1–6, July 2019.
12. Darsh Panchal, Aum Mandviwala, Pratik Patani, Fenil Soni and Shyam Doshi,[Utilization of Plastic Waste in Concrete as Fine Aggregate], International Research Journal of Engineering and Technology (IRJET), Volume: 07 Issue: 01 | Jan 2020.
13. Gopal Swarup Sangal, [Study the effect of plastic waste on strength of concrete], International Journal of Advance Research and Development, Volume 3, Issue 7, 2018.
14. Gaikwad M. N., Gunjawate Shubham A., Hole Gannesh Y, Kadam Mangesh
15. M. and Ghorpade Pratik A, [Experimental Study On Plastic Waste As A CoarseAggregate For Structural Concrete], International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321–8169 Volume: 6 Issue: 4, 2018.
16. Elango A and Ashok Kumar A, [Study On Partial Replacement Of Plastic WasteAs Fine Aggregate In Concrete], International Journal Of Current Engineering And Scientific Research (IJCESR), VOLUME-5, ISSUE-5, 2018.
17. Arivalagan.S, [Experimental Investigation On Partial Replacement Of Waste Plastic In Concrete], International Journal Of Engineering Sciences & ResearchTechnology, November, 2016.
18. T.Subramani and V.K.Pugal, [Experimental Study On Plastic Waste As A Coarse Aggregate For Structural Concrete], International Journal of Application
19. or Innovation in Engineering & Management (IJAIEM), Volume 4, Issue 5,May 2015, ISSN 2319 – 4847.
20. Veena N and S Sahana Sastry, [Evaluation of Strength And Durability of Waste Plastic Mix Concrete], IJRAR- International Journal of Research and Analytical Reviews, VOLUME 5 I ISSUE 3 I JULY– SEPT 2018.
21. M Mahesh, B Venkat Narsimha Rao and CH. Satya Sri, [Re-Use of Polyethylene Plastic Waste In Concrete], International Journal of Engineering Development and Research, 2016 IJEDR | Volume 4, Issue 4 | ISSN: 2321– 9939.
22. Sanjeet Kumar and Neha Singh, [A study on density by using plastic waste in Concrete Mix],

© STM Journals 2024. All Rights Reserved

International Journal for Research in Engineering Application & Management (IJREAM) ISSN : 2454–9150 Vol-04, Issue-02, May 2018.

23. B Jaivignesh and A Sofi, [Study on Mechanical Properties of Concrete Using Plastic Waste as an Aggregate], IOP Conf. Series: Earth and Environmental Science 80 (2017) 012016.
24. Manhal A Jibrael and Farah Peter, [Strength and Behavior of Concrete ContainsWaste Plastic], J Ecosys Ecograph, Volume 6 • Issue 2 • 1000186, ISSN: 2157–7625, 2016.

© STM Journals 2024. All Rights Reserved