Replacement of Sand with Shredded Plastic in Cement Concrete

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Abstract - the increasing demand for plastic materials due to population growth, leading to a rise in plastic waste generation. Simultaneously, the construction of buildings is increasing, causing a shortage of natural aggregates. To address both issues, the idea of using plastic waste in building construction by partially substituting natural aggregates with plastic waste is proposed. Various percentages of replacement (10%, 20%, 30%, 40%, and 50%) were examined, as complete replacement of natural fine aggregate with plastic fine aggregate is not feasible. The compressive strength and workability of concrete prepared with these different percentages of plastic fine aggregates was tested.

***Key Words*:** fine aggregate , natural aggregates, compressive strength, workability.

1. INTRODUCTION

Concrete, the second most utilized substance globally after water, stands as the foremost man-made material in construction. The prevailing challenge revolves around securing aggregates for concrete while addressing the disposal of diverse product waste. Presently, the construction sector emphasizes sustainability. This study presents a sustainable approach to managing plastic waste by utilizing shredded plastics to produce coarse aggregates, subsequently repurposing these plastics as earth fill. Rather than continual recycling, directing plastic waste towards concrete aggregate production could benefit the construction industry. The nation's escalating industrialization and urbanization spur numerous infrastructural developments, leading to a critical scarcity of building materials and heightened waste disposal concerns. Consequently, leveraging waste products as construction materials emerges as a solution to these issues. Following quality assessments and the substitution of a portion of the fine aggregate in concrete with plastic shreds, the optimal replacement percentage is determined. While extensive research has been conducted in countries like the USA and UK on this topic, studies on plastics in India remain notably limited

2. OBJECTIVE

Concrete ranks as the second most utilized material globally, following water. In India, the annual consumption of concrete stands at approximately 400 million metric cubic meters, a figure that continues to escalate. This surge in demand threatens to disrupt the equilibrium between material availability and necessity. Consequently, there arises a pressing need for an alternative material to alleviate this imbalance. This study proposes the utilization of shredded waste plastic as a viable alternative. The objectives of this research encompass exploring the effective utilization of shredded waste plastic and investigating its impact on the compressive and its workability.

2.1 MATERIALS

2.1.1. SHREDDED PLASTIC:

A Plastic Shredder is a machine used to cut plastic into smaller pieces for granulation or it's a waste plastic cut into number of small pieces is called as shredded plastic.

2.1.2. Fine Aggregate:

Fine aggregate was purchased which satisfied the required properties of fine aggregate required for experimental work and the sand conforms to zone III as per the specification of IS: 383:1970

2.1.3. Coarse Aggregate:

Crushed granite of 20mm maximum size has been used as coarse aggregate. The sieve analysis of combined aggregates confirms to the specifications of IS: 383:1970 for graded aggregates.

2.1.4. CEMENT: Ordinary Portland cement grade - 43 was used for the test. Which is confirming to IS 8112- 1989.

3. METHODOLOGY

Ordinary Portland cement of grade 43 was employed as the binding material, meeting the stipulations outlined in the Indian standards, IS 8112: 2013. Coarse aggregate was procured from a nearby quarry, while sand was acquired from a local supplier. Shredded plastic, sourced from a plastic waste factory, served as the alternative material. The concrete

mix adhered to a ratio of 1:1.5:3 by volume, serving as the control. Various percentages of shredded plastic, ranging from 1% to 4% by weight, were used to replace sand. A water-cement ratio of 0.45 was maintained throughout. Concrete production involved the thorough mixing of constituent raw materials in a concrete mixer. Nine specimens of each mix were fabricated, utilizing cast iron moulds measuring 150mm×150mm×150mm internally, as per IS: 456-2000 standards. Following a 24-hour casting period, the specimens were de molded and transferred to a curing tank until the day of testing. Compressive strength tests were conducted at 7, and 28 days of curing and tested on compression testing machine. On the testing day, specimens were removed from the curing tank, cleaned with a soft towel, and placed on the laboratory surface for analysis. Results presented reflect the average of three samples from the same mixture. All tests were conducted at the Concrete Technology laboratory within the civil engineering department.

3. RESULTS

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.

PLASTIC WASTE PERCENTAGE	COMPACTION FACTORS
0%	0.90
10%	0.86
20%	0.88
30%	0.87
40%	0.82
50%	0.80

TABLE 3.1 Compaction Factor of Concrete W.R.T. Plastic waste Percentage

Table 3.1 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

S No.	Control Mix	Slump(mm)
1	M20	75 mm

Table No. 3.2 Slump for Control mix of M20 grade concrete

S no.	Plastic waste	Slump(mm)
1	0%	70
2	10%	65
3	20%	63
4	30%	60
5	40%	59
6	50%	55

Table No. 3.3 Slump with Plastic waste

Compressive Strength

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.

Plastic waste (in %)	Compressive Strength (N/mm^2))	
	14 days	28 days
0%	22	28.44
10%	14.40	21.49
20%	14.91	23.74
30%	15.49	23.70
40%	15.75	22.49
50%	14.44	19.29

Table 1.4 Compressive strength of M20 grade

4. CONCLUSIONS

In this experiment, the mix design of M-20 grade concrete was conducted according to the reference IS 10262:2009, with a water-cement ratio of 0.45. Various percentages of plastic aggregates (ranging from 0% to 50%) were added to the concrete mix. Precise casting of specimens with plastic aggregates was carried out, followed by curing for 14 days and 28 days. Compaction factor tests and slump tests were performed during casting to verify the workability of the fresh concrete with different percentages of added plastic waste.

After the concrete reached its maturity period, compressive strength tests, split tensile tests, and flexural strength tests were conducted on all specimens, each cast on a specific date. Analysis of the results revealed that the compressive strength generally increased with the percentage of plastic aggregate up to 40%. However, beyond 40% of plastic aggregate, there was a decrease in compressive strength for both 14 days and 28 days cube strength. The study indicated that the optimal percentage increase in compressive strength occurred at 40% for both 14 days and 28 days.

This experimentation process and its findings provide valuable insights into the effects of incorporating plastic waste into concrete mixes, shedding light on its impact on both fresh and hardened concrete properties.

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