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Using Shredded Waste Plastics as Replacement for Coarse Aggregate

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Abstract

The paper examines the feasibility of using shredded waste plastics as a partial replacement for natural coarse aggregate in concrete, aiming to address plastic waste management challenges in India Standard mix designs for 25MPa concrete are utilized, with one control mix and four experimental mixes containing varying percentages of shredded waste plastics (0%, 25%, 30%, and 35%) by weight of coarse aggregate. A total of 72 cubes are produced for testing. The experimental results reveal that as the proportion of shredded waste plastics in concrete increases, there is a decrease in both tensile strength. However, at 28 days, the target strength of 25MPa is achieved by both the control concrete mix and the mix containing 25% shredded waste plastics. Previous studies referenced in the paper explore different approaches to incorporating waste plastics in concrete production, including substituting fine aggregate with PET processed particles, replacing natural fine aggregate with waste plastic, and producing lightweight aggregates from PET bottles. These studies report varying effects on concrete properties, including workability, density, and mechanical strength, with different percentages of waste plastic replacements.

Keywords: concrete mixes, mechanical strength experimental results, incorporating waste, waste plastic target strength, lightweight aggregates.

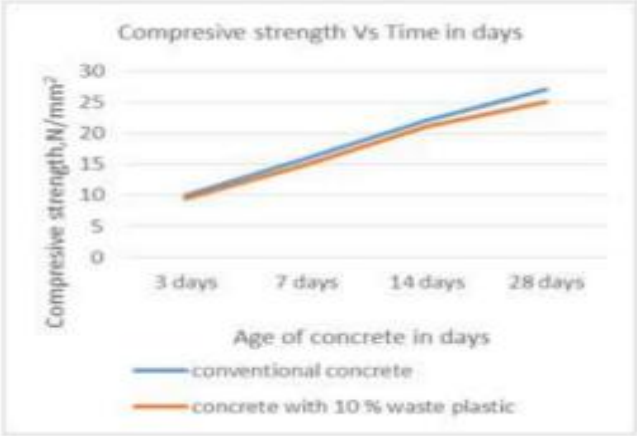
1. INTRODUCTION

India, with its population of over 1.4 billion, grapples with a staggering plastic waste challenge. On a daily basis, the country generates approximately 26,000 tonnes of plastic waste. To put this into perspective, that’s roughly equivalent to the weight of 26,000 small cars!. Plastics play a crucial role in the global economy due to their low cost, versatility, durability, and high strength-to-weight ratio. The plastics processing industry in India has grown significantly, with a Compound Annual Growth Rate (CAGR) of 10% in volume terms from 8.3 million metric tons per annum (MMTPA) in FY 10 to 13.4 MMTPA in FY15. It is expected to continue growing at a CAGR of approximately 10.5% from FY15 to FY20, reaching 22 MMTPA due to extensive applications. Government initiatives like "Make In India," "Skill India," and "Digital India" have contributed to the growth of plastic products in India. India's plastic consumption is approximately one-tenth of that in the United States. Let’s delve deeper into the specifics of plastic waste management in India during the 2023-24 period.

2. LITERATURE REVIEW

Sudarshan D. Kore (November 2019) The study addresses the pressing issue of solid waste management in our country by exploring the feasibility of using recycled plastic as a partial replacement for fine aggregate in concrete mixes. Given the non-biodegradable nature of plastic and the increasing production of solid waste, there's a critical need to find eco-friendly solutions. By incorporating plastic waste into concrete, the study aims to assess its impact on various mechanical properties such as workability, compressive, flexural, and split tensile strengths. The results indicate that replacing conventional fine aggregate with plastic aggregate enhances workability and fresh bulk density of concrete mixes. However, there's a marginal reduction in mechanical properties such as compressive, flexural, and tensile strengths, particularly up to 10% replacement levels. Overall, the study suggests that while using plastic waste in concrete mixes offers benefits in terms of workability and density, careful consideration is needed to mitigate any potential reduction in mechanical properties. Reuse of Waste Plastics in Developing Countries: Properties of Waste Plastic-Sand Composites-(Alexander Kumi-Larbi Jnr) (February 2022) The study explores the use of waste plastics, a significant issue in developing countries, as a low-cost recycling solution through plastic bonded sand composites. Research conducted in The Gambia demonstrates that processing waste plastics, particularly high-density polyethylene (HDPE), at temperatures between 250°C and 325°C yields optimal compressive and flexural strengths. HDPE exhibits higher maximum compressive strengths, reaching 37.1 MPa. Plastic bonded sand composites exhibit increased strength, toughness, and ductility, making them suitable for applications such as wall construction blocks and paving tiles. Overall, the research highlights the potential of plastic bonded sand composites as a sustainable approach to address plastic waste challenges in developing countries.

Karthikeyan M, Balamurali K, Barath Kumar V, Manoj Prabakar S And Janarthanan R. Published On- April 2019 The study investigates the utilization of waste plastic in concrete to enhance its mechanical properties. High-strength concrete with a water-cement ratio of 0.35 is prepared, with waste plastic replacing 10% of cement, fine aggregate, and coarse aggregate. Cubes and cylinders of specific dimensions are cast for testing. Previous studies by Khilesh (2014), Subramani and Pugal (2015), and Harini and Ramana (2015) are referenced, indicating the positive impact of incorporating plastic waste on concrete properties. Khilesh observed increased compressive strength with marginal reduction in slump, while Subramani and Pugal reported improved compressive, flexural, and split tensile strengths with 15% replacement level, but a decline beyond that due to excess water presence. Harini and Ramana found high workability and increased compressive strength with silica fume replacement. The study's test results demonstrate that 10% replacement yields compressive strengths of 9.5 N/mm² at 3 days, 15 N/mm² at 7 days, 21 N/mm² at 14 days, and 26 N/mm² at 28 days. Split tensile strengths increase to 1.07 N/mm², 1.5 N/mm², 2 N/mm², and 2.5 N/mm² respectively over the same period. Flexural strength gradually increases to 4.5 N/mm² at 28 days. However, detectable reductions in compressive strengths are noted with higher percentages of plastic replacement. Overall, the study suggests that incorporating 10% waste plastic in concrete can enhance its mechanical properties, but increasing the percentage of plastic may lead to diminishing returns in strength.



Compressive Strength

3. METHODOLOGY

Preparing the mix design of regular and plastic mixed concrete blocks.

Casting of regular and plastic mixed concrete cubes.

Curing of blocks cubes for 3, 7 and 28 days respectively.

To check the strength of the cube on a CTM Machine.

Comparing cement concrete blocks of grade m25 with plastic and regular concrete block

4. EXPERIMENTAL PROCEDURE

Concrete mix is the way by which we choose the different constituents used in the concrete

And determine their amount and by taking care of the economy and various properties of the

Concrete like workability, slump value, strength criteria etc. For designing the concrete mix,

We followed IS: 10262-2019. A design mix for M25 & M30 grade concrete was prepared and

Trial mixes were prepared to check the mix design and to adjust the amount of admixture and

Water cement ratio. The following parameters were used for mix design:-

Grade of Concrete: M25

Type of Cement: OPC - 43

Grade Cement Manufacturer: Ultra Tech

Zone of Fine Aggregates: Zone II

Sp. Gravity of Cement: 3.16

Sp. Gravity of Fine Aggregates: 2.60

Sp. Gravity of Course Aggregates of 20mm: 2.65

Water-Cement ratio: 0.45

For M25 Mix Design:-

For 1 cu.m.

Water – 178 lit.

Cement – 362 kg.

Admixture – 1% by wt. of cement.

Sand – 836 kg.

10mm – 465 kg.

20mm – 702 kg.

Unit of Batch	Replacement of plastic	Cement (kg)	Fine Aggregates (kg)	Coarse Aggregates (kg)	Plastic Aggregates (kg)	Water (lit.)
10mm						
For 15 cubes	0%	23 kg	52 kg	27 kg	-	11 lit
	15%			23 kg	4 kg	
	20%			22 kg	6 kg	
	25%			21 kg	7 kg	
20mm						
For 15 cubes	0%	23 kg	52 kg	41 kg	-	11 lit
	15%			35 kg	6 kg	
	20%			33 kg	9 kg	
	25%			31 kg	11 kg	

Unit of Batch	Mix Grades	Cement (kg)	Fine Aggregates (kg)	Coarse Aggregates (kg)	Water (lit.)
For 20MM Aggregate					
Cubic meter content. (for 84 cubes)	M25	23 kg/cu.m.	52 kg/cu.m.	41 kg/cu.m	11lit.
	For 10mm Aggregate				
	M25	23 kg/cu.m	52 kg/cu.m.	27 kg/cu.m	11 lit

5. CONCLUSION

The strength characteristics of plastic concrete mixers tend to decrease when a higher percentage of plastic aggregates are added. This may be due to the weakening of the adhesive force between the surface of the plastic materials and the cement paste. In addition, plastic is a hydrophobic material that does not participate in hydration. As we see today, the depletion of natural resources in the main parts, so we must move to our next option, which is plastic or recycled aggregate, so our research on plastic waste can show that we can provide a better choice for society and our world. Instead of coarse aggregates, plastic was added to the concrete in a proportion of 15%, 20%, 25%. Based on the results of this study, M25 mixed. The material used in the tests is good and working. The specific gravity of plastic was lower than that of fillers. In the experiment, it was observed that the compressive strength of concrete initially increased at 15 to 20 % PCA, but further increase in PCA shows a decrease in strength.

6. REFERENCES

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