

An Experimental Investigation on Partial Replacement of Fine Aggregate by Waste Plastic and Coarse Aggregate by C&D Waste in Concrete

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Abstract - This project is experimental research on the partial substitution of fine aggregate by plastic waste and coarse aggregate by construction and demolition (C&D) waste in concrete. The motivation is to seek alternative, sustainable ways of using conventional aggregates and minimize the environmental footprint of plastic and C&D waste. In this study, various concrete mixes were cast by partially substituting fine aggregates by shredded plastic waste and partially substituting coarse aggregates by C&D waste. Standardized tests were performed to assess the workability, compressive strength, and overall performance of the modified concrete. The findings confirmed that the presence of plastic waste and C&D materials significantly affected the workability and mechanical properties of the concrete. Although, compressive strength reduced with higher levels of replacement, some combinations were still above the required level of strength for structural purposes. This experiment illustrates the possibility of utilizing recycled waste and non-biodegradable materials in concrete to ensure sustainability, along with efficient waste management for the construction sector.

Key words: Cement, Coarse Aggregate, Construction and Demolition (C&D) Waste, Fine Aggregate, Plastic Waste

INTRODUCTION

The construction industry is growing rapidly due to urbanization and infrastructure development. This growth has increased the demand for natural resources such as river sand and crushed stone, which are important materials for making concrete. Excessive use of these natural aggregates leads to environmental problems like riverbed degradation, soil erosion, and loss of biodiversity. At the same time, disposal of plastic waste and construction and demolition (C&D) waste has become a major environmental issue. Large amounts of plastic and demolished concrete are dumped in landfills, causing land pollution, groundwater contamination, and drainage problems. Therefore, there is a strong need to find sustainable and eco-friendly alternatives in construction. This project focuses on the partial replacement of fine aggregate with waste plastic and

coarse aggregate with C&D waste in concrete. Waste plastic, especially polyethylene (PET), is widely used in packaging materials such as bottles and containers. After its use, it becomes waste and is mostly disposed of in landfills. Using this plastic waste in concrete is one effective method of recycling and reducing environmental impact. Similarly, C&D waste such as crushed concrete from demolished buildings can be processed and reused as coarse aggregate. This reduces the demand for natural aggregates and supports the concept of a circular economy.

The main aim of this study is to evaluate the feasibility, strength, durability, and environmental benefits of concrete made with different percentages of plastic waste and C&D waste. The use of these materials is expected to reduce waste disposal problems, conserve natural resources, and promote sustainable construction practices.

LITERATURE REVIEW

Tushar R Sonawane et.al. (2013) said use of recycled aggregate in concrete can be useful for environmental protection. Recycled aggregates are the materials for the future. **M. Subramani and Pugal (2015)** reported that, the use of plastic waste as a replacement for conventional coarse aggregate improves the physical and mechanical properties of concrete mixes. As the percentage of replacement increased beyond 15% all the properties of concrete showed downward trend. **Mahesh et.al. (2016)** prepared Concrete with 2%, 4%, 6% pulverized/non pulverized polyethylene material is prepared after doing the mix design and concluded Waste plastic can be effectively re-used without affecting the mechanical properties considerably (10-15%). **Karthikeyan (2019)** investigated the effect of using waste plastic materials on the concrete. Detectable reductions in compressive strengths are observed with increasing the percentage of plastic. **Riyas PR et.al. (2020)** investigated use of waste plastic PET bottles in concrete and concluded 5-15% replacement of fine aggregate by shredded PET bottles, the mechanical properties (compressive strength, split tensile strength, and flexure strength) remains close to the reference concrete. **Prof. Vimal N. Patel et.al. (2020)** concluded water absorption of RCA was 3 times higher and specific gravity of

is 15% to 16% lower than the NA. The compressive strength of RAC at 100% replacement level is decreased by 27% and 29.23%, while at 50% replacement level it reduced by 16.9% and 15.72 % in M20 and M30 respectively compared to reference concrete. 30% RA replacement in RAC shows only 4.13% and 8.35 % reduction in M20 and M30 respectively which is not significantly different from the conventional concrete. **B. Varalaxmi et.al. (2021)** said as per the results obtained in the present investigation we have observed that the value of the strength parameters of the concrete prepared by using the recycled aggregates has been gradually increasing. The cube compressive strength of recycled aggregate concrete with partial replacement of 10%, 20%,30% natural aggregate is increased by 4.25% more than conventional concrete compared to self-compacting concrete cube strength. **Dr. G. Hathiram et.al. (2023)** concluded the use of recycled aggregate has been found to be better than that of natural aggregate.

MATERIALS

The detail of various materials used in the experimental investigation will be:

- Sand - The fine aggregate used was M-sand passing through 4.75 mm sieve. The grading zone II of fine aggregate was as per IS specification.
- Coarse Aggregate - Crushed stone aggregate of maximum size 20 mm
- Cement - Pozzolana Portland Cement (fly ash based)
- Water - Ordinary clean potable water free from suspended particles and chemicals was used for mixing and curing concrete.
- Plastic Waste - Shredded plastic waste of PET bottles
- Construction & Demolition Waste - Construction and demolition waste is generated whenever any construction/ demolition activity takes place

METHODOLOGY:

- To investigate the use of waste plastic and C&D waste as fine and coarse aggregates replacement in concrete, cubes of M25 grade having proportion 1:1.382:2.489 having w/c ratio 0.43 were casted using following replacement percentages and were cured for 3, 7, 14, 21 and 28 days and were tested for compressive strength. The proportion of concrete mix materials for M25 are calculated by mix design calculation and justified by conforming the specifications mentioned in IS: 10262-2019.
- Concrete cube mold of specimen size 150 mm x 150 mm x 150 mm generally compacted by 3 rounds of tamping (each round consists of 25 tamps) to ensure proper compaction.
- The compressive strength is taken as maximum compressive load resisted by per unit area.
- After leaving for 24 hours for proper setting specimens were demolded and allowed for curing for gaining its optimum strength till the date of testing.

Proportion	Fine Aggregate		Coarse Aggregate	
	% M-Sand	% Plastic	% Natural Aggregate	% C&D Waste Aggregate
P1	100	0	100	0
P2	85	15	100	0
P3	80	20	100	0
P4	75	25	100	0
P5	100	0	70	30
P6	100	0	60	40
P7	100	0	50	50
P8	85	15	70	30
P9	80	20	60	40
P10	75	25	50	50

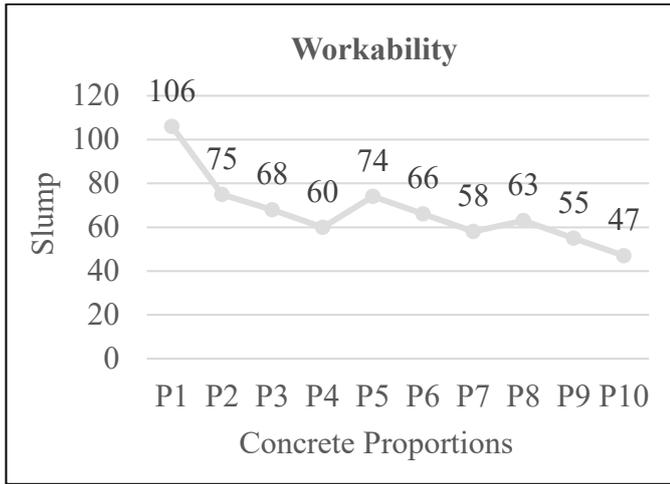
Table 1: Different proportions of concrete cubes casted

TEST RESULTS FOR M25 GRADE CONCRETE:

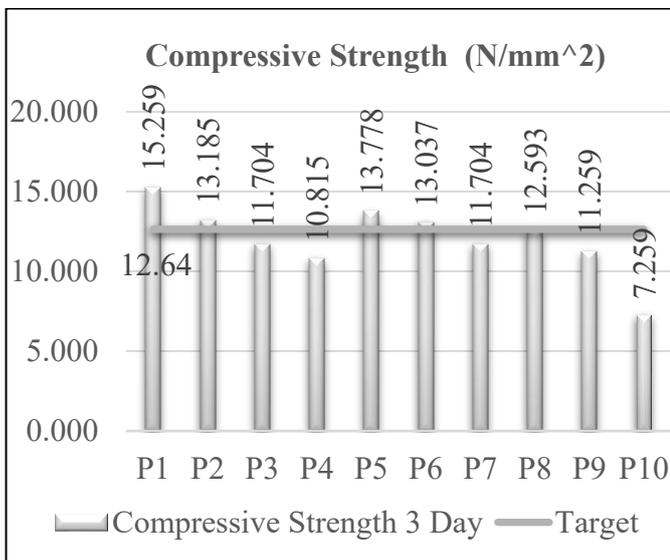
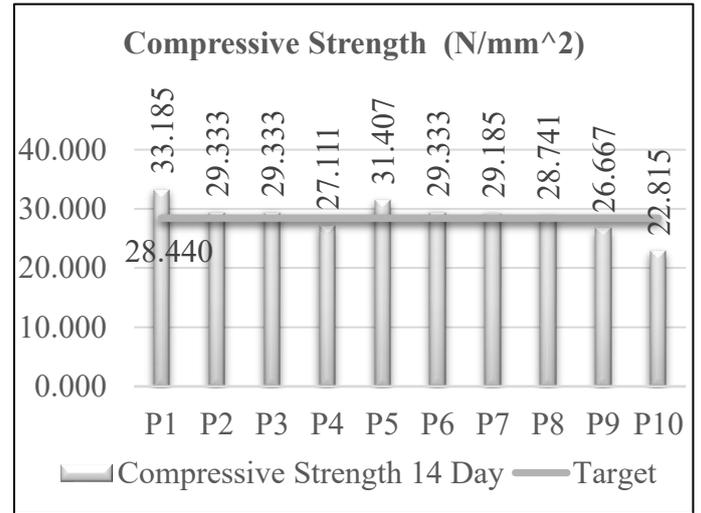
The concrete cubes were tested in Compression Testing Machine. The tests were carried out at Shri Siddheshwar Women's Polytechnic, Solapur for M25 grade of concrete.

Proportion	Slump (mm)	Compressive Strength (N/mm ²)				
		3 Days	7 Days	14 Days	21 Days	28 Days
Target	--	12.640	20.540	28.440	29.072	31.600
P1	106	15.259	23.556	33.185	34.519	35.704
P2	75	13.185	20.889	29.333	31.556	33.037
P3	68	11.704	20.148	29.333	30.667	31.852
P4	60	10.815	18.370	27.111	29.778	30.222
P5	74	13.778	22.074	31.407	33.185	34.074
P6	66	13.037	20.889	29.333	31.556	33.333
P7	58	11.704	19.111	29.185	30.519	31.259
P8	63	12.593	21.333	28.741	29.778	31.704
P9	55	11.259	18.222	26.667	28.889	29.185
P10	47	7.259	15.704	22.815	24.296	25.926

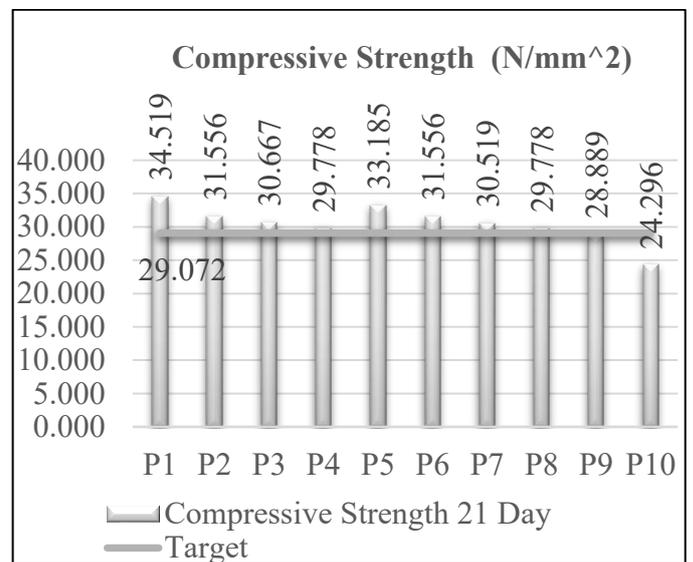
Table 2: Compressive strength of concrete



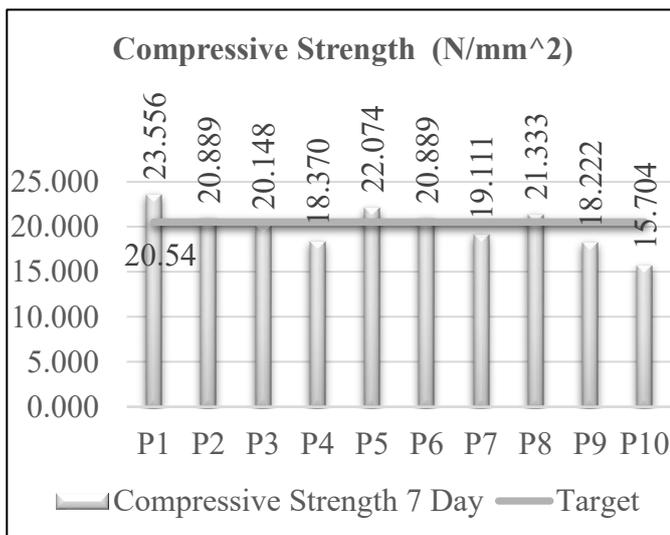
Graph 1: Workability for different concrete proportions



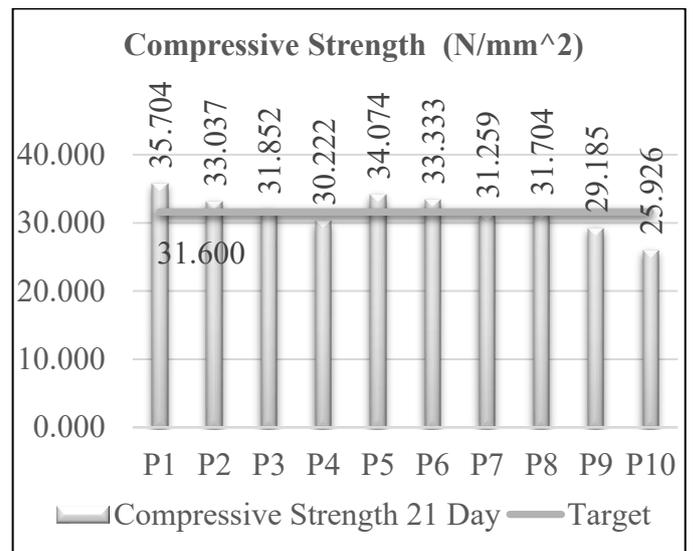
Graph 2: Compressive strength of concrete after 3 days of curing



Graph 5: Compressive strength of concrete after 21 days of curing



Graph 3: Compressive strength of concrete after 7 days of curing



Graph 6: Characteristic compressive strength of concrete

Graph 4: Compressive strength of concrete after 14 days of curing

CONCLUSIONS

The experimental study on M25 grade concrete incorporating plastic waste as partial replacement of fine aggregate and C&D waste as partial replacement of coarse aggregate shows that moderate replacement levels can produce sustainable concrete without significantly affecting strength. Workability decreases with increasing replacement percentages, but compressive strength generally increases with curing age. Plastic waste replacement up to about **15–20%** and C&D waste replacement up to **30–40%** provide strength comparable to conventional concrete. The optimal combined replacement level was found to be **15% plastic waste and 30% C&D waste**, which satisfies the strength requirements of M25 grade concrete while promoting sustainable use of waste materials.

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