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Mechanical Properties of Concrete with Partial Replacement of Coarse Aggregate by Waste Bottle Caps and Fine Aggregate by Quarry Dust

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Abstract : This paper represents the comparative experimental data on the mechanical properties of partially replaced concrete under compression, split tensile and flexure. Design mix of M30 grade concrete with replacement of 1.5%, 2%, 2.5%, of waste bottle caps as a coarse aggregate and 50 % of quarry dust as a of fine aggregate. The compressive strength, split tensile strength and flexural strength of concrete are found at the age of 28 days is obtained at room temperature.

Key words : Waste bottle caps, quarry dust, compressive strength, split tensile and flexural test.

Introduction

Concrete is the most widely used man made construction material in the world and its second only to water as the most utilized substance in the planet[1]. Concrete is the most widely used construction material worldwide, this is due to its versatility, strength, durability and ease to place into forms and shapes [2].

In the present study the bottle caps were used to prepare the coarse aggregate there by providing a sustainable option to deal with the bottle caps[1] .To confirm that rapid increase in the construction activities lead to acute shortage on conventional building materials. The slump, split tensile strength, compressive strength, flexural strength properties at different percentages replacement of coarse aggregate with waste bottle caps were investigated in the laboratory[4,5] .These aggregates are lighter in weight compared to stone aggregate. Today the construction industry is in need of finding effective materials for increasing the strength of concrete structures with low cost, and with less environmental damage. This research is aimed at addressing such issues by investigating the possibility of using bottle caps to partially substitute for coarse aggregate.

Fine aggregate is an essential component of concrete. The most commonly used fine aggregate is natural river sand. For the past two years, the escalation in cost of sand due to administrative restrictions in India, demands comparatively greater cost at around two to three times the cost for crusher waste even in places where river sand is available nearby[3]. In the present work, Quarry dust is used as a partial replacement material of fine aggregate in concrete. The quarry dust is the by-product which is formed in the processing of the granite stones which broken downs into the coarse aggregate of different sizes[4] .Quarry dust has been proposed as an alternative to river sand their gives additional benefit to concrete. Quarry dust is known to increase the strength of concrete over concrete made with equal quantities of river sand, but it causes a reduction in the workability of concrete Waste minimization. The M30 grade of concrete was designed by using the codal provisions of IS 10262-2009[8].

2.0 Material Properties and Methodology

2.1 Cement

Cement is the most important constituent of concrete, it forms the binding medium for the discrete ingredients made out of naturally occurring raw materials and sometimes blended or inter-ground with industrial wastes. Cement comes in various types and chemical compositions. "Portland pozzolana cement" 53 grade of cement is used for concrete[5]. The properties of cement were determined and results are given in the table.

Table 1. Test results of cement

S.no	Test	Result
1	Consistency	35%
2	Initial setting time	30 min
3	Final setting time	10 hours
4	Specific gravity	2.9

2.2 Fine Aggregate (FA)

The sand used for the experimental procedure was locally procured from a river and confirmed to Indian Standard Specifications. It was passed through a 4.75mm sieve, washed to remove any dust and then used as it was for further investigations[4]

Table 2. Test results of sand

S.no	Test	Result
1	Sieve analysis of sand	Zone I
2	Moisture content	1%
3	Specific gravity	2.64

2.3 Coarse Aggregate (CA)

Broken granite stones are generally used as a Coarse Aggregates (CA).Locally available CA having the maximum size of 20mm was used in our work. The aggregates were washed to remove any dust and were dried. The Aggregates were tested as per Indian Standard Specifications. The grading of aggregate should be conformed to the requirement as per IS: 383-1970[9]

Table 3. Test results of coarse aggregate

S.no	Test	Result
1	Specific gravity	2.74
2	Moisture content	0.5%

2.4 Quarry Dust (QD)

The quarry dust is the by-product which is formed in the processing of the granite stones which broken downs into the coarse aggregates of different sizes.[4] Quarry dust has the same physical characteristics to sand. It was made to pass through a 4.75 mm sieve, washed and used for further studies.

Table 4. Test results of quarry dust

S.no	Test	Result
1	Specific gravity	2.6
2	Moisture content	Nil

2.5 Waste Bottle Caps (WBC)

Large quantities of metal waste are generated from empty metal cans and bottle caps of juices and soft drinks [2].This is an environmental issue as metal waste is difficult to biodegrade and involves processes either to recycle or reuse. Today the construction industry is in need of finding effective materials for increasing the strength of concrete structures with low cost.

Fig.1.waste bottle caps

2.6 Water

Water is an important ingredient of concrete as it initiates the chemical reaction with cement, and mix water was completely free from chlorides and sulfates. Ordinary portable water without acidity and alkanet available in pump as per IS: 456-2000[10].

2.7 Mix Proportion

As per the code IS: 10262 –1979 [8], the mix design is found and the amount of materials is Calculated. According to the mix ratio, the amount of materials is given below, in Table 5.

Table 5: Detail Mix Proportions.

Cement	Fine aggregate	Coarse aggregate
562.8 kg/m^3	622 kg/m^3	1060.9 kg/m^3
1	1.1	1.89

2.8 Casting

The concrete should be deposited and placed at the required place on formwork. While placing the concrete there should not be segregation and bleeding. After the concrete is deposited, it is compacted to achieve the maximum density.

Table 6: Specimen Details

S.no	Specimen	No of ordinary specimen	Bottle caps with quarry dust (50%)		
			1.5%	2.0%	2.5%
1	Cube	3	3	3	3
2	Cylinder	3	3	3	3
3	prism	3	3	3	3

3.0 Tests on Concrete

3.1 Workability of Fresh Concrete

Workability can be demarcated as the quantifiable internal work essential to wholly compact the mass of concrete without the effect of bleeding or segregation, for a freshly prepared concrete, which can be tested by many test like slump cone apparatus and the compaction factor analysis.

3.1.1 Slump Test

The slump cone test determines the workability of a freshly mixed concrete compiling to the standards of IS: 1199- 1959[12], which measures the consistency of concrete in a particular and specific batch. The slump test is the most well-known and widely used test to characterize the workability of fresh concrete.

Table 7. Slump values for W/C 0.35

S.no	% of CA Replaced by WBC & FA by QD (50%)	Slump (mm)
	M30	
1	0	10
2	1.5	8
3	2.0	8
4	2.5	8

3.2 Tests on Hardened Concrete

In the concrete structures design, engineers refers to the hardened state properties like compressive strength, flexural strength and split tensile strength of concrete. For compressive strength test, cube specimens of dimensions 150 x 150 x 150 mm per IS 516:1999[13] were casted for M30 grade of concrete.

Compressive strength = Load / Area

For tensile strength test, cylinder specimens of dimension 150 mm diameter and 300 mm length per IS516:1999[13] were cast.

Split tensile strength = 2P / πLD

For flexural strength test, prism specimens of dimensions 700 x 150 x 150 mm were cast[13]

Flexural strength = 3 P a / b d^2

The specimens were demoulded after 24 hours of casting and were transferred to curing tank wherein they were allowed to cure for 28 days.

Fig 2.Testing of cubes Fig 3.Testing of cylinders Fig 4.Testing of prism

4.0 Results and Discussion

The compressive strength, Split tensile strength, Flexural strength test results for M30 grade concrete are shown in the Tables 8, 9 and 10 respectively.

Table 8. Compressive strength test results,

% of WBC and QD (50%)	Average weight	Average load	Compressive strength (N/mm^2)
0	8.42	1050	46.67
1.5	8.50	710	31.55
2.0	8.42	860	38.22
2.5	8.56	920	40.88

Table 9. Split tensile strength test results.

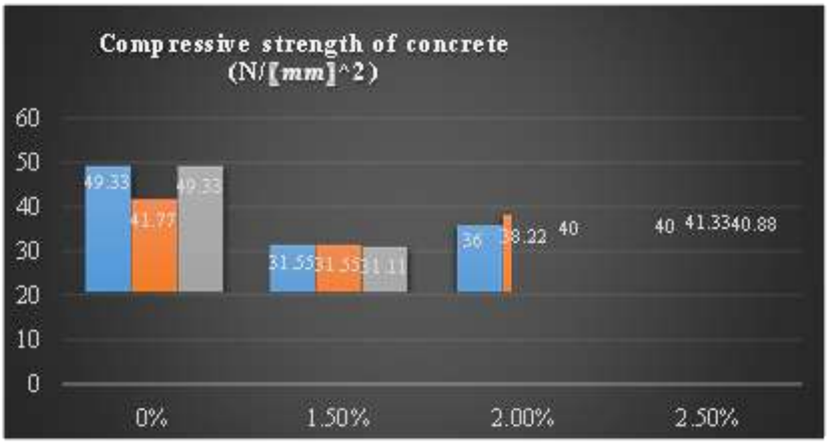
% of WBC and QD (50%)	Average weight	Average load	Split tensile strength (N/mm^2)
0	13.16	195	2.75
1.5	13.11	195	2.75
2.0	13.14	185	2.62
2.5	13.10	195	2.75

Table 10. Flexural strength test results.

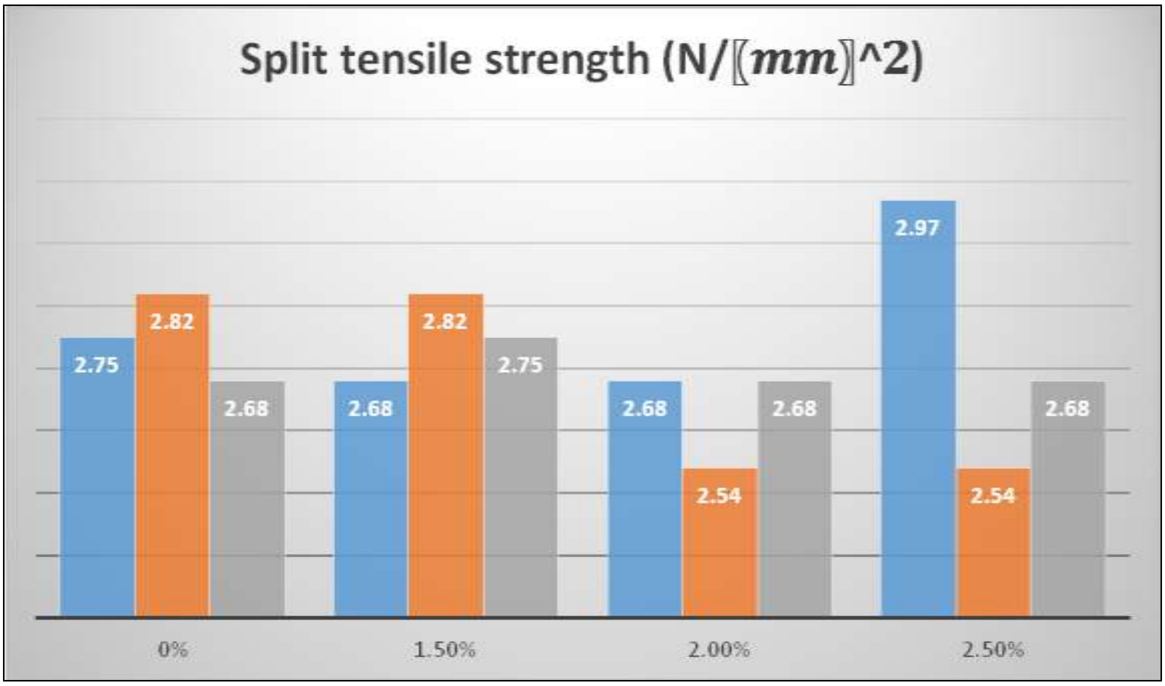
% of WBC and QD (50%)	Average weight	Average load	Flexural strength (N/mm^2)
0	39.13	25.33	9.00
1.5	39.08	22.33	7.93
2.0	38.29	21.33	8.07
2.5	38.92	27	9.76

4.1 Graphical Representation of Results

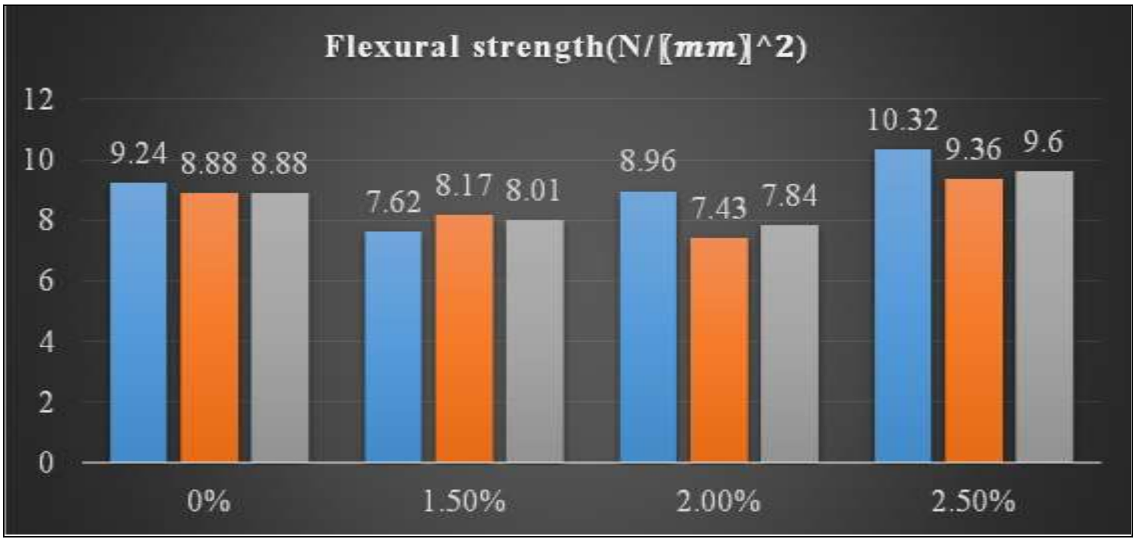
The results of concrete cubes, cylinders, prism with waste bottle caps and quarry dust replacement obtained at age of 28 days is as represented in Figures 3, 4 and 5 respectively.



% WBC and QD (50%)
Fig 4.Compressive strength results



% WBC and QD (50%)
Fig 5.Split tensile strength results



% WBC and QD (50%)
Fig 6.Flexural strength results

5.0 Conclusion

The following conclusions were drawn from the experimental investigation**.**

1. The compressive strength of the concrete is higher when there is no replacement of waste bottle caps and quarry dust.
2. The split tensile strength of the concrete is higher when there is no replacement of waste bottle caps and quarry dust.
3. The flexural strength of the concrete is higher when fine aggregate is replaced by 50% of quarry dust and coarse aggregate is replaced with 2.5 % of waste bottle caps.
4. The strength of concrete increases with increase in percentage of replacement of coarse aggregate with waste bottle caps.
5. Due to replacement of fine aggregate the demand on fine aggregate also gets reduced.

6. Environmental wastes which pose a difficult problem in its disposal can be efficiently addressed through the results of this research.

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