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Experimental Study on the Hardened Properties of Concrete by Using Soft Drink Bottle Caps as Partial Replacement for Coarse Aggregates

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ABSTRACT

Cement concrete is the most extensively used construction material in the world because of its great workability and can be moulded to any shape. Ordinary cement concrete possesses a very low tensile strength, limited ductility and little resistance to cracking because of the presence of internal micro cracks, which leads to failure of the concrete. In this modern age, civil engineering constructions have their own structural and durability requirements, depending upon its purpose and for this, modification in traditional cement concrete is must. Addition of different types of fibers to concrete in specific percentage improves the mechanical properties, durability and serviceability of the structure. It is learnt that Steel Fiber Reinforced Concrete (SFRC) has its superior resistance to cracking and crack propagation. Hence an attempt is made to study the influence of cut bottle caps as a steel fiber concrete as partial replacement for coarse aggregates and studying the parameters like compressive strength, split-tensile and flexural strength of conventional and steel fiber reinforced concrete Therefore it can be seen that compressive, split-tensile and flexural strength of fiber reinforced concrete has been increased as compared to conventional concrete by replacing coarse aggregates with bottle caps.

Key Words: *Bottle Caps, Steel fibers, fiber reinforced concrete, compressive, split-tensile and flexural strength.*

1. INTRODUCTION

Initially, fibers are used to prevent and control plastic and drying shrinkage in the concrete. After the research and improvement, it has been understood that the addition of fiber materials in the concrete can also improve the other concrete properties such as flexural toughness, flexural strength fatigue resistance, impact resistance, and post-crack strength.

Concrete is weak in tension and has a brittle character. The concept of using fibers to improve the characteristics of construction materials is very old. Alternatively, introduction of fibers in discrete form in plain or reinforced concrete may provide a better solution [1]. Fiber reinforcement is now considered as the most effective way of improving the resistance of concrete to cracking. During the last two decades, numerous fiber types made from many different materials (steel, polypropylene, nylon, carbon, etc.) have been developed and successfully used to reinforce concrete. While the primary purpose of fiber reinforcement has so far been to improve the toughness and energy absorption of concrete, it is becoming apparent that the real benefit of fiber reinforcement may in fact be in improving the physical and durability properties of concrete. [2] Experimental studies proved that fibers improve the mechanical properties of concrete such as flexural strength, compressive strength, tensile strength, creep behavior, impact resistance and toughness [3]

2. MATERIALS

2.1 Cement:

Ordinary Portland cement of Grade 43 [Birla gold] conforming to IS: 8112-1989 was adopted in this work [4], The properties of the same are given in Table 1.

2.2 Coarse aggregates:

The aggregates used in this project are mainly of basalt rock which comes under normal weight category. The aggregates are locally available. 50% of the aggregate used are of 10-12mm size and remaining 50% are of 20mm size. The impact value and crushing value is 7.49% and 24.40% respectively. Specific gravity is 2.67, and fineness modulus is 7.2 and all are under limits and were tested in accordance to Indian Standard specifications IS: 383-1970 [5].

2.3 Fine Aggregates:

Clean River sand is used as fine aggregate. The specific gravity and fineness modulus were found to be 2.63 and 2.64 respectively. Sieve analysis was done to find out fineness modulus which is obtained as 3.14% which is under limits as per IS 383-1970. The properties are tested as per [5]

2.4 Fiber material:

Bottle caps of soft drink bottles were collected and cut into small pieces. They are similar to the steel fibres but they don't have any regular shape and size. The dimension varies with nature of sources and upon the type of industries. Scraps considered in this work are 0.5 mm thick, 3 mm approximate width which are added to the concrete as steel fibers as shown in figure 1.

Figure 1: Sources of bottle caps and sample of fiber

3. Methodology

3.1 Concrete Mix Design

In the present study, M20 grade with nominal mix as per IS 10262-2009 is used as per [6]. The concrete mix proportion (cement: fine aggregate: coarse aggregate) is 1: 1.5: 3 by volume and a water cement ratio of 0.5.

3.2 Experimental programs

Totally 45 cubes, 45 cylinders and 45 beams were casted. Metal caps were partially replaced with coarse aggregates in concrete in 5 different percentages starting from 0%, and increasing the mixing of metal caps up to 4%, at an interval of 1.0%. For each percent of metal cap fiber addition, 3 cubes, 3 cylinders and 3 beams were casted. Final strength of cubes, cylinders and beams were tested after 7, 28 and 45 days of curing. Compression testing machine was used for testing the compressive strength of cubes [150 X 150 X 150] mm, split tensile strength of cylinders [Ø 150 mm, height 300 mm] and flexural strength test on beams of size [100X 100 X 100 mm] by Universal Testing Machine. Specimen details are given in table 2. [7, 8, 9, 10]

Table 1: Cement test results

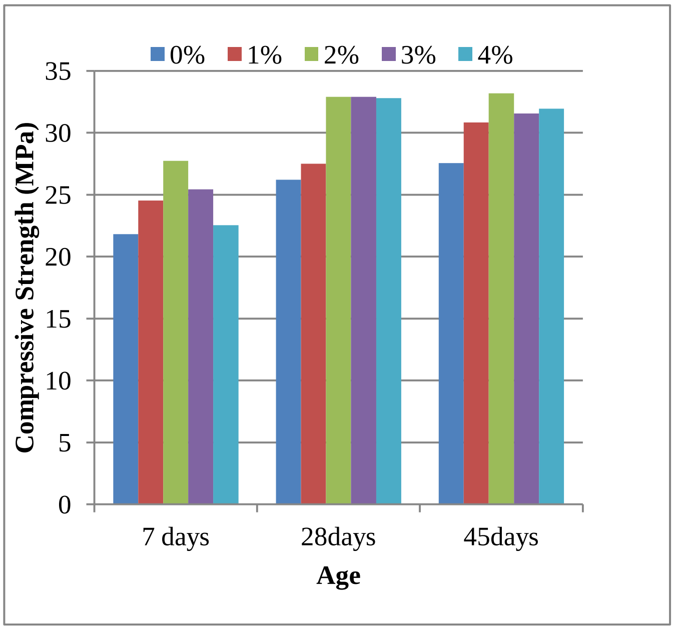
S. No	Characters	Experimental Value	As per IS 8112:1989
1	Consistency of Cement	31.0%	-
2	Specific Gravity	3.13	3.15
3	Initial Setting Time	36min	>30min
4	Final Setting Time	472min	<600min
5	Fineness of Cement	9%	10%

Table 2: Details of specimen

S.No	Specimen Details	Name of speciman	No. of Specimen
1	Normal Concrete (N C) + 0% fiber	N1	3
2	N C + 1% of Fiber	N2	3
3	N C + 2% of Fiber	N3	3
4	N C + 3% of Fiber	N4	3
5	N C + 4% of Fiber	N5	3

Table 3: Test Results of 7, 28 and 45 - Days compressive Strength of Concrete

Name of Specimen	% of bottle caps used	Average strength at 7, 28 and 45 days in (N/mm^2)		
		7-day strength (MPa)	28-day strength (MPa)	45-day strength (MPa)
N1	0	21.81	2.22	27.54
N2	1	24.52	27.51	30.83
N3	2	27.74	32.91	33.18
N4	3	25.42	31.32	31.57
N5	4	22.54	32.79	31.95

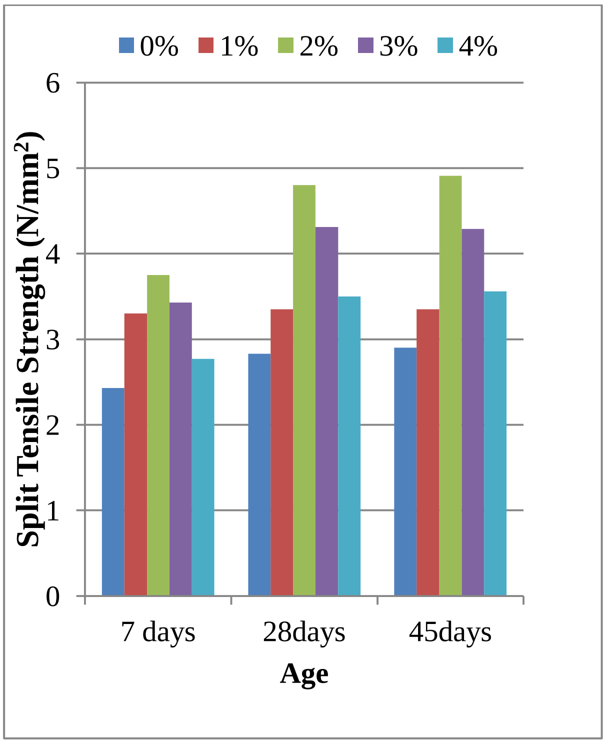


Graph 1: Compressive strength of SFRC at different addition levels for 7, 28 and 45-days

The Graph 1 indicates that the compressive strength of 45-days is more than that of 28-days. The optimum strength gained is at 2% replacement of coarse aggregates by bottle caps as fibers to concrete and lowest strength at 0% replacement for all 7, 28 and 45 days period of curing.

Table 4: Split Tensile strength at 7, 28 and 45-days for various additions of bottle caps

% of Bottle Caps Used	7-day strength (MPa)	28-day strength (MPa)	45-day strength (MPa)
0%	2.43	2.83	2.90
1%	3.30	3.35	3.35
2%	3.75	4.80	4.91
3%	3.43	4.31	4.29
4%	2.77	3.50	3.56



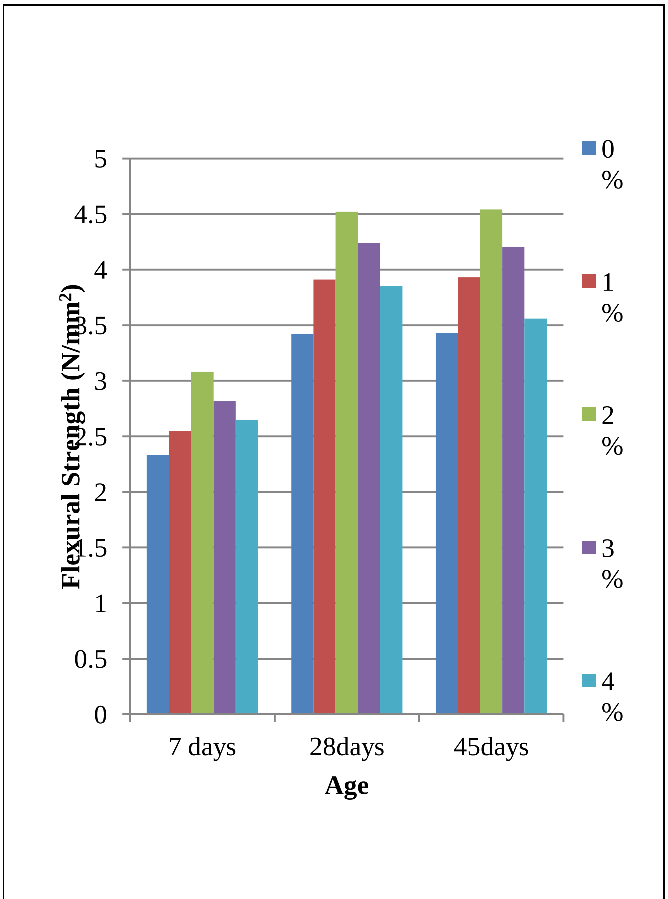
Graph 2: Split-tensile strength at different additions levels for 7, 28 and 45-days

The Graph 2 indicates that the compressive strength of 45-days is more than that of 28-days. The optimum strength gained after 28 and 45-days curing period is at 2% addition and the lowest strength at 0% addition of bottle caps as fiber to concrete.

Figure 2: Typical compressive failure pattern of concrete Cubes

Table 5: Flexural strength at 7, 28 and 45-days for various additions of bottle caps

% of Bottle Caps Used	7-day strength (MPa)	28-day strength (MPa)	45-day strength (MPa)
0%	2.33	3.42	3.43
1%	2.55	3.91	3.93
2%	3.08	4.52	4.54
3%	2.82	4.24	4.2
4%	2.65	3.85	3.88



Graph 3: Flexural strength at different additions levels for 7, 28 and 45-days

The Graph 3 indicates that the flexural strength of 45-days is more than that of 28-days. The optimum strength gained after both 28 and 45-days curing period is at 2% addition and the lowest strength at 0% addition of bottle caps as fiber to concrete.

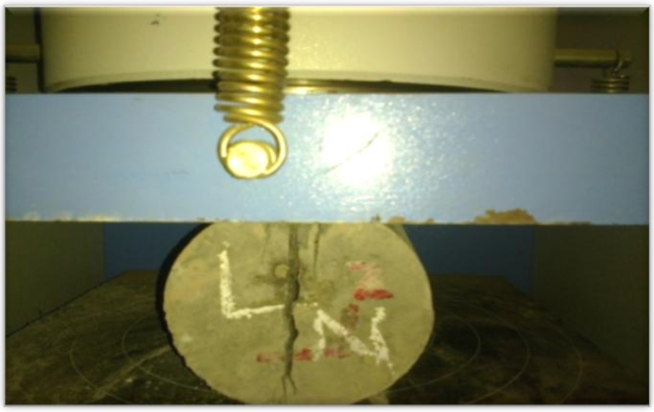


Figure 3: Typical Tensile Failure pattern of concrete Cubes

Figure 4: Typical Flexure Failure pattern of concrete Cubes

5. Results and Discussion

- It can be observed from the Graphs 1, 2, 4 that, the compression, split tensile and flexural strength of concrete can be increased by increasing the percentage of fibres added to it. The above graph indicates that the compressive strength of 45-days is more than that of 28-days. The optimum strength gained is at 2% replacement of coarse aggregate by bottle caps as fiber to concrete and lowest strength at 0% replacement for all 7, 28 and 45 days period of curing.
- The Graph 2 indicates that the compressive strength of 45-days is more than that of 28-days. fiber
- The Graph 3 indicates that the flexural strength of 45-days is more than that of 28-days. The optimum strength gained after both 28 and 45-days curing period is at 2% addition and the lowest strength at 0% addition of bottle caps as fiber to concrete.

6. Conclusion

The conclusions that can be drawn from this research based on the experimental results are as follows:

- Addition of steel fibers increases flexural and compressive strength of concrete to larger extent
- In flexure the specimen with soft drink bottle caps as waste material was found to be good. By the addition of scrap steel fibers, the flexure strength was found to increase to a greater extent than that of the conventional concrete.
- The various percentage of fiber at a dosage of 1%, 2%, 3% and 4%, the compression, tensile and flexural strength has been altered compared to normal concrete.
- The percentage increase in tensile strength of steel scrap fiber reinforced concrete is more as compared to its compressive strength.
- The results indicated that the compressive, split-tensile and flexural strength of fiber reinforced concrete has been increased when compared to the conventional concrete at 2% addition of steel fiber reinforced concrete (SFRC).
- Since, bottle caps of soft drinks are easily available, they can be easily collected and cut into fibers and the compressive strength can be increased to it some extent.

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