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INNOVATIVE AND SUSTAINABLE APPLICATION OF SOFT DRINK BOTTLE CAPS AS FIBER IN CONCRETE STRUCTURES

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ABSTRACT:- *Advancements in technology enhance not only human comforts but also damage the environment. Use of steel fiber has become popular and safe now. Today the construction industry is in need of finding cost effective materials for increasing the strength of concrete structures. Hence an attempt has been made in the present investigations to study the behavior of* ***f****iber reinforced concrete in a composite material consisting of cement based matrix with an ordered or random distribution of fiber which can be steel, nylon, polythene etc. The concrete incorporate with steel fiber increases the properties of concrete, viz., flexural strength, compression strength, tensile strength and shrinkage properties to name a few. This paper presents a detailed experimental study on fiber reinforced concrete at age 28 days. The main variable investigated in this study is variation of bottle cap fiber dosage of 0.1%, 0.2%, 0.3%, and 0.4% by volume of concrete. Experimental investigation was done using C20, C25 and C30 mix and tests were carried out as per recommended procedures by relevant Ethiopian & BIS codes. Test results indicate that the use of bottle caps fiber in concrete has improved the strength of concrete. The study is conducted on a 1:1.5: 3 nominal concrete mixes, with specimen sizes (150mm× 150mm × 150mm). The test results are compared for Compressive and split tensile concrete strengths, with and without use of fibers*

Key Words: *Sieve Analysis, Compressive Strength, Flexural strength, Spit Tensile strength, Water Absorption.*

I. INTRODUCTION

In Ethiopia, most industrial and domestic activities are associated with significant amounts of non-biodegradable solid waste, which include a wide range of plastic waste. The research studies to be undertaken intended to determine the efficiency of reusing waste soft drink bottle caps in production of plastic block. Utilization of these waste materials is a partial solution to environmental and ecological Problems. Use of plastic not only helps in getting them utilized in such types of material, it helps in reducing the cost of concrete making. Aggregates are used in a variety of building applications, and can be said to be the largest quantity of material used in any industry. Almost all aggregates are produced from natural resources such as gravel pits, river beds and rock quarries. In addition to depleting these natural resources, mining for aggregates also poses serious environmental risks like disturbance of natural habitats and creating open areas with no vegetation, therefore recycling of this material has also indirect benefits such as reduction landfill cost, saving energy, and protecting the environment from possible pollution effects. At a time when landfill space is becoming almost impossible due to increasing land value, then recycling and reuse of wastes as beneficial products should be strongly encouraged and examined. One potentially strong and viable market is to develop recyclable wastes into construction material, a common material used throughout the construction industry. The reuse of waste materials in building construction is a great idea, and the high demand for construction materials makes them a favorable medium in which to reuse recyclable materials. Concrete in general, weak in tensile strength and strong in compressive strength. The main aim of researchers or concrete technologists is to improve the tensile strength of concrete. To overcome this serious defect partial incorporation of fibers is practiced. Great quantities of steel waste fibers are generated from industries related to lathes, empty beverage metal cans and soft drink bottle caps. This is an environmental issue as steel waste fibers are difficult to biodegrade and involves processes either to recycle or reuse. Fiber reinforced concrete is an interesting topic discussed by numerous researchers in the last two decades.

II. RESEARCH METHODOLOGY

2.1. MATERIALS USED:

(A) CEMENT: Ordinary Portland cement 52.5 grade conforming to ASTM-1997 was used.
(B) FINE AGGREGATE*:* Clean River sand is used as fine aggregate. The specific gravity and fineness modulus were found to be 2.64 and 2.83 respectively. The properties are tested as per ASTM-1997.
(C) COARSE AGGREGATE*:* In the present study 55% of the coarse aggregate is used of size 14 mm and 45% is of size 10mm. Mix proportion of concrete as per the codal provision.

(D) FIBER MATERIAL: Bottle caps of soft drink bottles were collected and then crushed to get the required fiber material as shown in fig 1.

Fig 1 Sample of fibers

2.2. Concrete Mix Design:

Table 1: Details of Sample preparation

Sl. No	Sample preparation details	Cube	Cylinder	Prism
1.	Natural Aggregate (Sp1)	3	3	3
2.	Natural Aggregate+ 0.1% of fibre(Sp2)	3	3	3
3.	Natural Aggregate+0.2% of fibre (Sp3)	3	3	3
4.	Natural Aggregate+0.3% of fibre (Sp4)	3	3	3
5.	Natural Aggregate+0.4% of fibre (Sp5)	3	3	3

2.3. Sample Product Preparation:

Step 1: Generally, the soft drink bottle caps were collected from different cafeteria, hotels, small shops, bus stands, factory areas, college restaurants & different places of Universities & towns. That caps were not in use & also these were used for construction materials by different research ideas & methods. These plastic bottle caps were collected & crushed to get required fiber material by using mechanical machines in workshop.

Step2: The required quantity of cement, sand & aggregate were mixed with the adequate percentage of plastic crushed material according to codal provision. Hence mixing process should not consume more time.

Step 3: The mixture is then poured into the block of mould. Before placing the mixture into the mould, the sides of the moulds are oiled to easy removal of the sample. After that Pours the mixture in to the mould by spade and compacted by using steel rod until the adequate compaction level reached, the surface is finished by using trowel.

Step 4: Finally, the mould has removed carefully so that the plastic blocks are not damaged, because release is immediate and occurs with no problems, by carefully removing the mould. By applying same procedure, we were prepared cylinder & prism.

III. EXPERIMENTAL RESULT & DISCUSSION

The quality test is conducted to compare the results of the sample product to the standard material requirement (concrete cube, cylinder & prism) according to ASTM.

3.1. Sieve Analysis: Table 2: Sieve analysis test results for fine aggregates (BS882:1992)

Sieve size	Mass retained (gm)	% of cumulative retained by mass	% of pass by mass	Specification
10mm	0	0	100	100
5mm	20	2	98	89-100
2.36mm	120	14	86	60-100
1.18mm	210	35	65	30-100
600µm	190	54	46	15-100
300µm	240	78	22	5-70
150µm	220	100	0	0-5
Total	1000	283	Fineness modulus = 2.83	

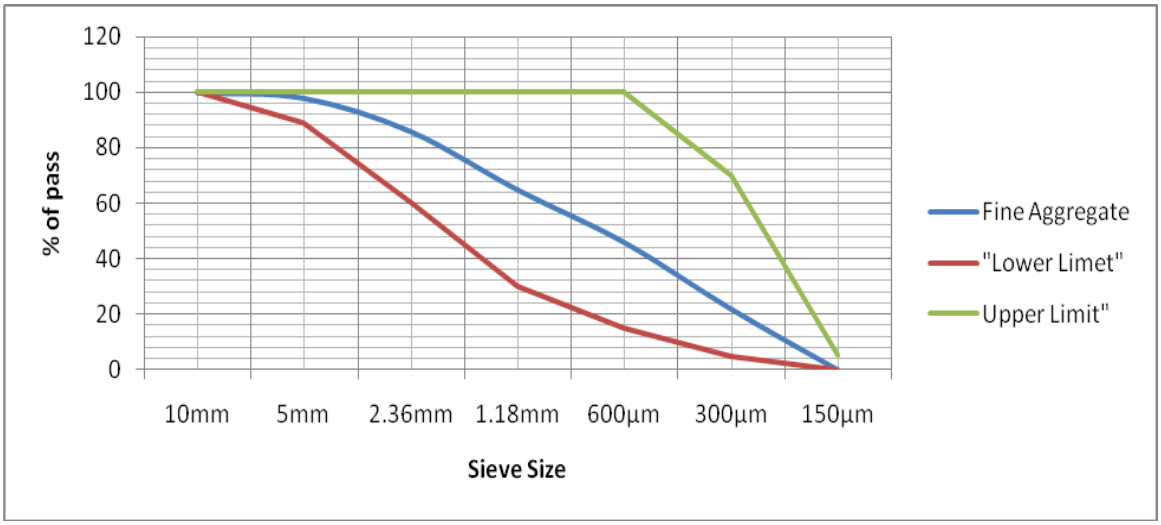

Fig:2:Fine Aggregate

Table 3: Sieve analysis test results for coarse aggregates (BS882:1992)

Sieve size	**Mass retained (gm)**	**% of cumulative retained by mass**	**% of pass by mass**	**Specification**
50mm	0	0	100	100
37.5mm	0	0	100	100
20mm	50	5	95	85-100
14mm	250	30	70	0-75
10mm	450	75	25	0-25
5mm	200	95	5	0-10
2.36mm	50	100	0	0
Total	1000			

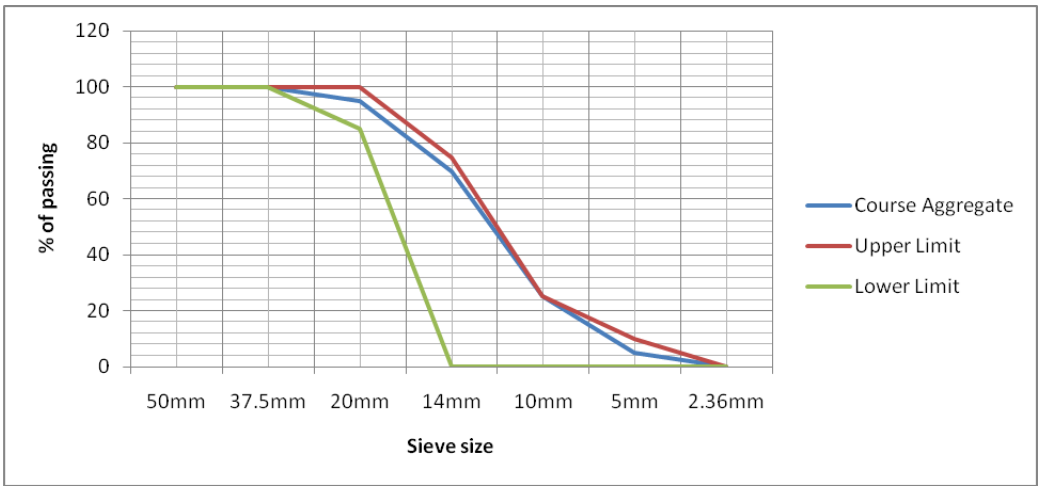

Fig: 3: Coarse Aggregate

3.2. Compressive strength test result:

Table 4 Result of Average Compressive Strength of Concrete

% of fiber	C 20	C 25	C 30
0	27.3	33.2	38.5
0.1	30.3	34.2	39.8
0.2	33.7	37.2	42.3
0.3	39.7	43.2	48.3
0.4	45.3	50.2	55.3

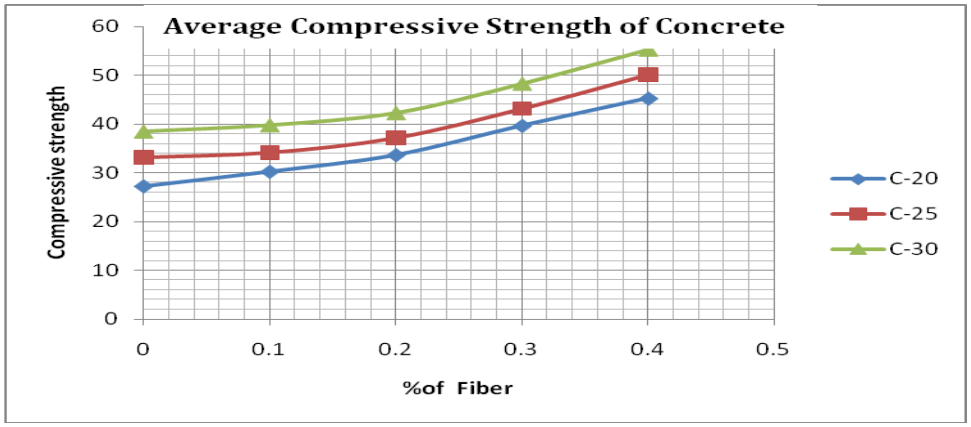

Fig 4: Compressive strength & % of fiber

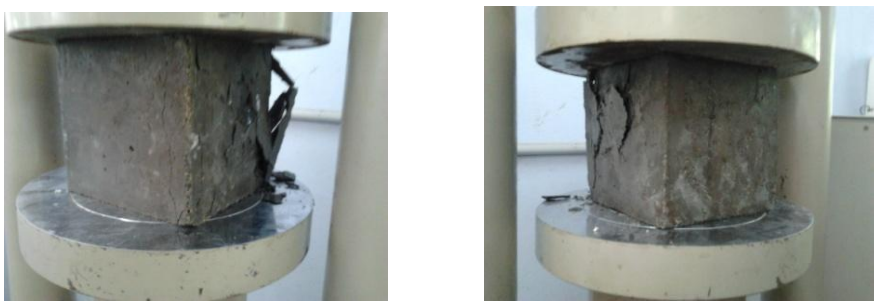

Fig 5: Failure pattern of the specimen

●It can be seen from the experimental investigation that addition of 0.1% fiber increases 10.981% in C20, 3.012% in C25 and 3.377% in C30. By adding 0.20 % fiber compressive strength has increased by 12.462% in C20, 8.772% in C25, 6.03 % in C30. Then by adding 0.3% fiber compressive strength has increased by 17.804% in C20, 16.129 % in C25, 14.18% in C30. And by adding 0.4% fiber the compressive strength has increased by 14.106 % in C20, 16.204 % in C25, 14.493

% in C30. From the results, increase in percentage of fiber reinforcement increases the compressive strength of the concrete.

●In this research the values of block compressive strength for different addition of plastic contents (0.1%, 0.2%, 0.3% and 0.4%) is studied. From the Fig 4 graph above, there is abruptly increased in compressive strength. According to ASTM C129, standard specification for non-load bearing wall masonry the minimum average compressive strength is 600 psi (4.14 MPA), but as we see in the above result is under our limitation.

3.3. Flexural strength test results:

Table 5 Result of Average flexural strength of concrete

% of fiber	C20	C25	C30
0	3.35	3.87	4.09
0.1	3.52	3.96	4.17
0.2	3.72	4.19	4.41
0.3	3.97	4.47	4.68
0.4	4.11	4.62	4.83

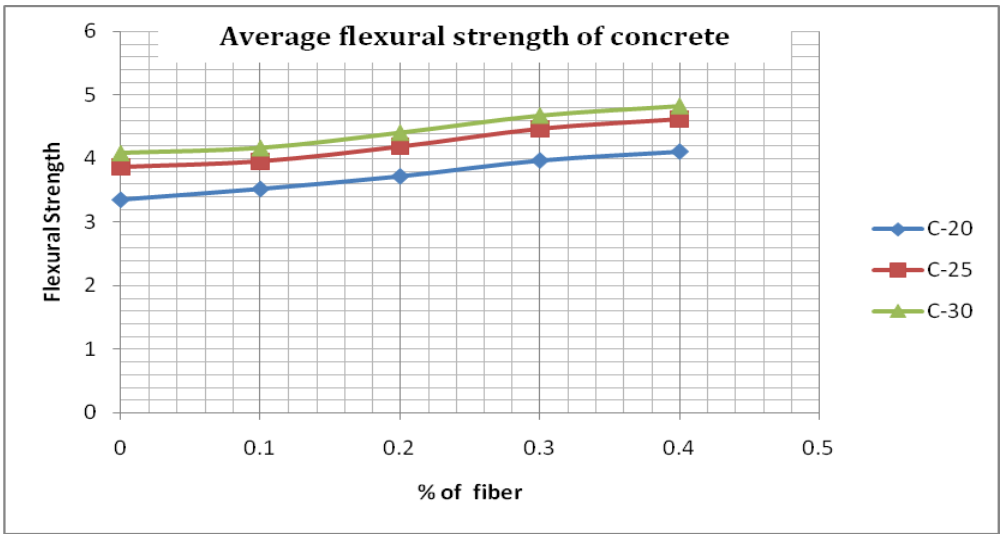

Fig 6 Flexural strength of concrete & various % of fiber

Fig 7 Failure pattern

The experimental results showed that the flexural strength of concrete specimens has increased as the fiber content got increased. The flexural strength of C20 grade concrete included with steel fiber has been increased by 5.07 %, 5.68 %, 6.72 % and 14.01 % for 0.1%, 0.2%, 0.3% and 0.4% respectively. The flexural strength of C25 grade concrete added with steel fiber has been increased by 2.32 %, 5.808 %, 6.68 % and 3.356 % for 0.1%, 0.2%, 0.3% and 0.4% respectively. Similarly the flexural strength of C30 grade concrete incorporate with steel fiber has been increased by 1.956 %, 5.755 %, 6.122 % and 3.205 % for 0.1%, 0.2%, 0.3% and 0.4% respectively.

3.4. Tensile strength test results:

Table 6: Results of split tensile strength test

% of Fiber	C20	C25	C30
0	2.53	2.84	2.98
0.1	2.61	2.92	3.12
0.2	2.75	3.13	3.27
0.3	2.92	3.24	3.43
0.4	3.12	3.43	3.73

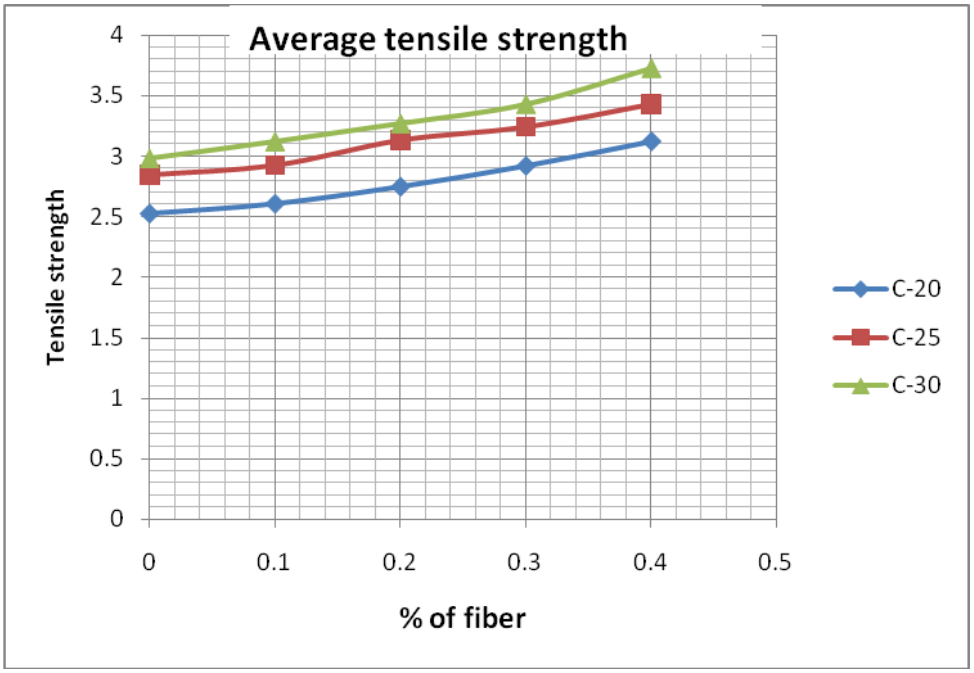

Fig 8 Tensile strength of concrete & various % of fiber

Fig 9. Failure pattern

●The test results showed that the splitting tensile strength of concrete specimens increased as the fiber content increased. The tensile strength of C20 grade concrete incorporate with steel fiber has been increased by 3.162 %, 5.364 %, 6.182 % and 6.849 % for 0.1%, 0.2%, 0.3% and 0.4% respectively. The tensile strength of C25 grade concrete incorporate with steel fiber has been increased by 2.817 %, 7.192 %, 3.514 % and 5.864 % for 0.1%, 0.2%, 0.3% and 0.4% respectively. Similarly the tensile strength of C30 grade concrete incorporate with steel fiber has been increased by 4.698 %, 4.808 %, 4.893 % and 8.746 % for 0.1%, 0.2%, 0.3% and 0.4% respectively.

3.5. Water Absorption Test Results:

Table 7: Result of Water Absorption Test (%)

% of Fiber	C20	C25	C30
0	14.63	12.24	10.76
0.1	11.52	10.36	9.12
0.2	6.75	5.13	3.27
0.3	2.72	1.91	0.97
0.4	1.92	1.43	0.56

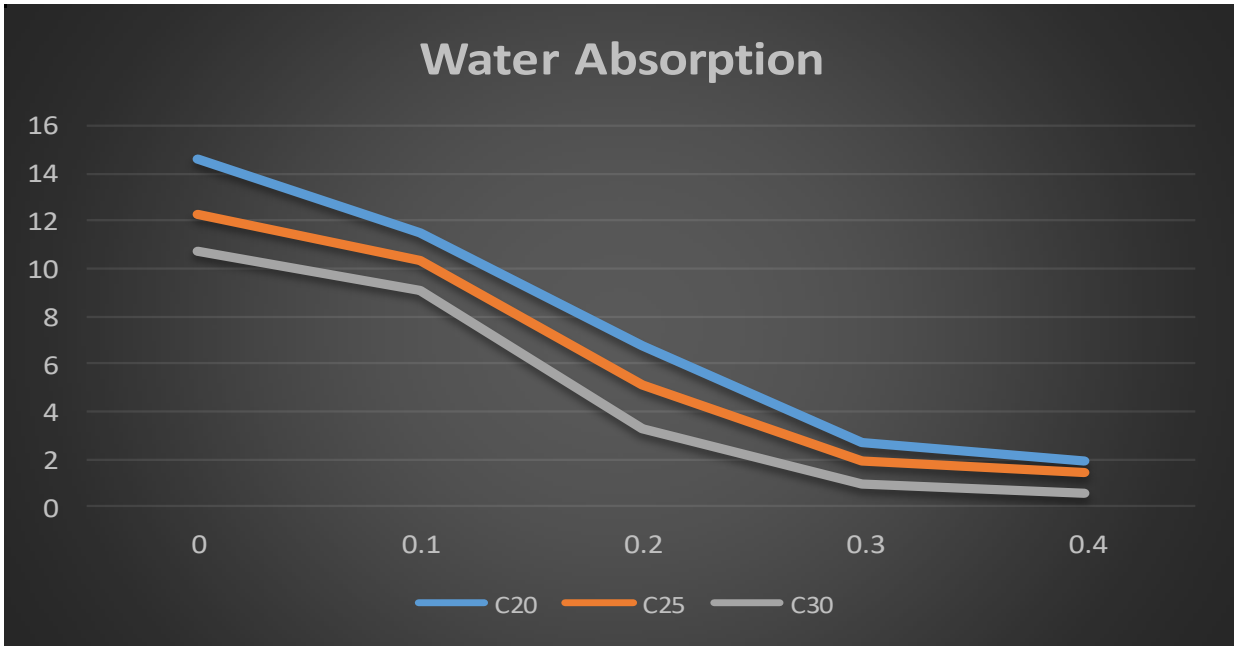

Fig: 10 Water Absorption & % of fiber

●In the above figure 10, where the absorption satisfied the standard for all the proportion, the water absorption of 3.72 percent which was far below the standard of 5 %. The maximum water absorption recommended Based on ASTM C936 is 5 %, but our result is between 6.21% up to 1.79 % as shown in the above. From this experiment, we finally got the conclusion that.as soon as the fiber percentage is increased, water absorption percentage is decreased.

3.6. Slump Cone Test Results:

Table 8: Result of Slump Cone Test (Observed Value in mm)

Sl No	**Mix Proportion (%)**	**Low Strength Concrete (C20)**	**Intermediate Strength Concrete (C25)**	**High Strength Concrete (C30)**
1	0.1	40	69	131
2	0.2	35	61	112
3	0.3	27	57	92
4	0.4	26	54	87

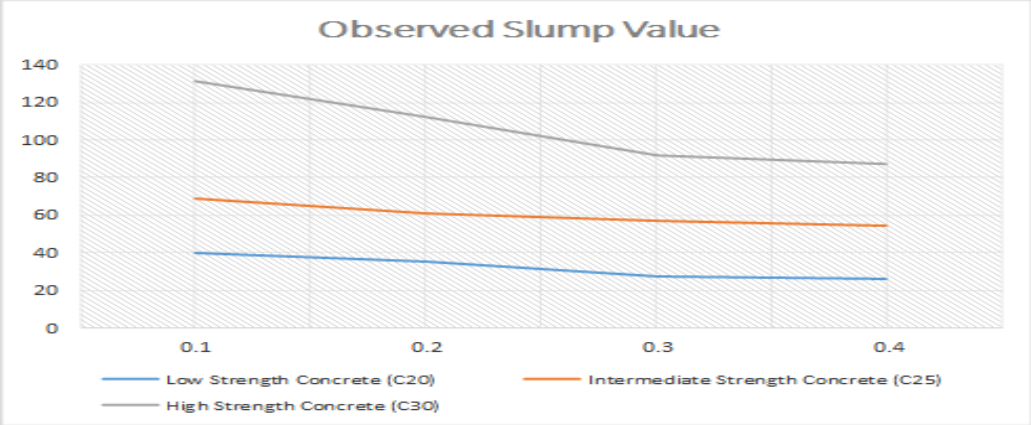

Fig: 11 Slump Cone observed value & % of

Fig.12 Slump Cone Test

●From the above observed value of the slump cone test table, we are concluded that, the slump value are in between 25 to 50 mm for low strength concrete, 50 to 75 mm for intermediate strength concrete & 75 to 150 mm for high strength concrete according to ASTM.As soon as the fiber percentage increases, the slump value decreases

●Generally slump is the difference between the height of mould & height point of the subside which is shown in the above figure. In this experiment, the apparatus are metallic mould in the shape of frustum cone, taping rod with bullet end, measuring scale or tape, trowel & metallic sheet which are shown in the above figure.13.

IV. CONCLUSION

The following conclusions are presented based on experimental results from the present investigation.

- Admirable Split tensile strength was achieved with the addition of steel fibre in concrete. The tensile strength has been increased up to 8.746 % when compared to that of the conventional concrete.

- The various percentage of fiber at a dosage of 0.1%, 0.2%, 0.3 % and 0.4 % the compressive strength has been increased in all above various mixes. Bottle caps used as fiber enable the large utilization of waste product. 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 its greater extent.
- The various percentage of fiber at a dosage of 0.1%, 0.2%, 0.3 % and 0.4 % the flexural strength has been increased in all above various grade of concrete. Hence the bottle caps used as fiber enable the large utilization of waste product. Since, bottle caps of soft drinks are easily available, they can be easily collected and cut into fibers and the flexural strength can be increased to its greater extent.
- The various percentage of fiber at a dosage of 0.1%, 0.2%, 0.3 % and 0.4 % are increased, the water absorption decreased in all above various grade of concrete.
- The various percentage of fiber at a dosage of 0.1%, 0.2%, 0.3 % and 0.4 % are incresed,the observed value of slump are decreased in all above various grade of concrete & also satisfied the ASTM conditions.

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