Experimental Investigation on Usage of Waste Bottle Caps as Fiber in Concrete

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Abstract — Concrete with fiber reinforcement is a composite material composed of fibrous material that provides structural strength and integrity. Since, concrete is significantly brittle in nature and exhibits the poor tensile strength, the cracks are obtained at a faster rate and thus effects the reinforcement and starts to corrosion of steel. So, to overcome this issues the fibers are induced in concrete to prevent cracking and improve the strength. The addition of the bottle caps as fibers increases the strength parameters of the concrete. The compressive load carrying capacity induced with the bottle caps as fibers has provided greater strength but as the increase in the bottle caps as fibers the strength gradually decreases. The split tensile load carrying of concrete increases with induction of bottle caps as fibers in which the experiment up to 15% the bottle caps are added and the strength is increased. The flexural strength gets higher due to induction of the addition of the bottle caps up to 10% but after increasing the bottle caps as fibers to 15% the strength gradually decreased. The results from the experiment conclude that the compressive, split tensile, flexural strength of the concrete induced with the bottle caps as fibers to 10% is greater than the nominal mix.

Keywords: Waste Bottle Caps, Fiber, Concrete

I. INTRODUCTION

Concrete is a heterogeneous mixture of solid masses made by cementing medium, the general ingredients are cement, sand, gravel and water with their well-defined properties. Concrete is frequently utilised material in construction in every part of the world. It can be casted to any shape and suitable for all types of construction. It is generally used for construction of highways, streets, parking lot, bridges, high rise buildings, and other applications. The major impact in modern construction is regarded between the steel and concrete. As concrete is strong in compression and weak in tension and brittle in nature. Basically in all type of construction the steel is utilised as the main reinforcement to obtain greater tensile strength to equally sustain the loads which are imposed on the concrete.

The other alternative for the usage of steel in concrete is cost and other parameters is by utilising the readily available material which can be utilised is the fibres. The material is available in various types in which based on the specific type of the works the suitable type of the fibres is utilised. The waste by products from industries was first introduced and utilised in construction in overall globe. It was utilised as the secondary reinforcement in concrete. At the todays scenario it is being utilised as the main reinforcing in construction to obtain the greater strength. They are being utilised in almost major projects like slabs, foundation, tunnels segments, pre stressed elements.

A. *The main objective of the project*

1) To investigate the ultimate load capacity on concrete induced with the bottle cap as fibres.
2) To compare the strength characteristics of bottle cap fibres induced concrete with respect to the nominal concrete.

B. *Scope of the Study*

The scope of this study is mainly to attain the objectives which are mentioned above and the study is mainly concentrated on the experiments. The experiments regarding the different testing such as the compression strength, split-tensile strength, flexural strength of the concrete by introducing the bottle caps as fibres in the concrete in different ratios and studying the behaviour of this concrete. All the testing methods and procedures are specified and followed as per the Indian Standard.

C. *Summary of the research*

The studies that have been carried out on fiber reinforced and the concrete induced with the bottle cap as a fibers various investigations have been summarised and presented above. The literature has provided the brief of concrete induced with bottle caps as fibers. Keeping the objective of research in mind the complete review of findings of the studies performed with reference to the properties of the concrete with the bottle cap as fibers has been made. The bottle caps as a fibers utilised in the concrete is an attempt is made to find the strength characteristics on the concrete and thus the utilisation of the waste bottle caps in the concrete as a fibers and thus reducing some amount of waste and contributing in reusing them as fibers in the concrete and thus improving the different strength parameters of the concrete.

II. METHODOLOGY

This chapter is mainly concerned with testing the materials which is used in conduction of the project. The methodology which gives a through description of the aspects which were adopted during the course of the project, to achieve the objectives of the project. To find the strength parameters of the concrete compared to the nominal concrete.

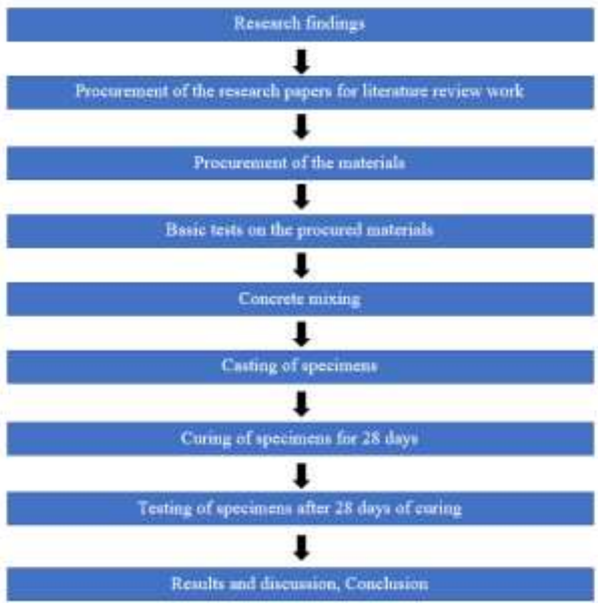


Fig. 1:

Materials used

The properties of the various materials used in the project has been discussed in brief in this stage.

1) Cement
2) Fine aggregate
3) Coarse aggregate
4) Water
5) Bottle caps as fibers

A. Cement

Cement is one the main requirement in concrete in which the cement acts as the binding material in which the cement has the property of setting and hardening once comes in contact with water. The cement is manufactured by process of burning and crushing the natural cement stones, which contains the argillaceous and calcareous content. The obtained raw material is burnt in a very high temperature and grinding the burnt mixture to fine powder. Ordinary Portland cement of 43 grade is used in the project.

B. Fine aggregates

The material which has size less than 4.75mm passing is termed as fine aggregate. The M-sand which is available nearby is utilised in the project.

C. Coarse aggregate

The material which are retained on the 4.75mm sieve is termed as the coarse aggregate. The coarse aggregates are obtained by crushing the rocks into pieces, natural crushed aggregates are obtained in different sizes in which the 20mm down size aggregate is used in this project.

D. Water

The water is important ingredient which is required in concrete in which it helps in setting of the concrete, once the cement comes in the contact with water the concrete starts to hardening in which the hydration of the cement takes place. The quantity of the water is calculated based on the type of the concrete which is required. The water which is used in the concrete should be free from organic matters and alkalies, chemicals and salts the water utilised must be a portable water which is available in the place.

E. Bottle caps of the waste soft drink bottles

The bottle caps of the soft drink bottle caps are gathered from many sources in which the bottle caps are dumped and thus the bottle caps are similar to the steel fibers in which they possess the same similarities and the properties of the bottle caps are similar to that of the steel fibers. The usage of the bottle caps as the fibers in the concrete can improve the overall strength parameters of the concrete by mainly concentrating on the tensile strength of the concrete. The dimensions of the caps varies to the collected material in which generally the caps are in the circular shape with punched in the centre. But while utilising the caps the bottle caps are flattened and thus cutted into 4mm width into pieces and thus by inducing the bottle caps fibers in the concrete in the fibers way such that the workability of the concrete is not affected thus it is utilised in the concrete.

Fig. 2:

F. Mould and its specifications

The moulds of cubes, beams and cylinders were used in the casting of the concrete. In which the bottle caps as fibers were used in the concrete in 3 ratios to that of cement, ratios from 5%, 10% and 15%. To each ratios the 5 specimens were casted. In which the normal concrete specimen was also casted and later the final str5enght of the cube, beam, and cylinders were tested for 7days, 28days after curing. The compression testing machine is utilised for testing the compressive strength of the cubes of size 150mm X 150mm X 150mm. the cubes used for casting the concrete are IS standard cubes.

The split tensile strength of the concrete was tested using the compression testing machine in which the cylinders were utilised to cast the concrete of size 150mm dia and 300mm height.

Flexural strength of the concrete tests has been done by using the beams of the size 100mm X 100mm X 500mm by using the universal testing machine.

III. MIX PROPORTIONING

The M30 concrete grade was utilised is designed and utilised in the project for both nominal and bottle caps as fiber in concrete.

A. Normal Moulds, Trays

Concrete is generally mixed in the flat trays which are non-absorbent in which first the every materials are weighed and batched separately and in first the fine aggregate and cement is poured and mixed equally and then the gravel is then added and then mixed proportionally the bottle caps fibers are induced to mix and then mixed proportionally so that bottle caps fibers do not get separated. The admixtures named as superplasticizers are measured and then added to water and to the dry mix. The mixing should be continuous to prevent the hardening of concrete. The mix is done equally until the uniform mix is obtained then it is poured to the different moulds.

B. Mixing of the materials

The materials are weighed separately first and then each of the materials are mixed manually. The fine aggregate and cement are mixed first and then gravel and the bottle caps as fibers and finally the water as per the water cement ratio is utilised by adding the superplasticizers to water and the mix is performed equally and uniformly. The concrete are placed in to the moulds in 5 layers in which each layers are tamped by usage of tamping rod 16mm dia and 600mm in length with the bullet pointed in the front. The moulds should be carefully fitted properly to prevent the leakage of the mortar from the gaps so the ends of the moulds should be tightened properly. The tamping is done equally to spread the concrete all over and to prevent any air voids and gaps in the concrete. The tamping is done uniform all over the area, the excess tamping should be prevented since it leads to the segregation. The each layer tamping is done by giving 25blows per layer and followed for the next layer and casting is done.

C. Demoulding of Specimens

The demoulding samples are done after 24hrs of casting in which the demoulding of the cubes, beams and cylinders are done in the next day after casting in which the demoulding can be delayed due to concrete hardening property if the concrete is fresh in state and not hardened the demoulding can be delayed for another 1 day. The demoulding process the sample is separated from the mould completely. After demoulding top surface of concrete is marked with the marker by naming the cubes for identification. The next step is to cure the sample in water for the specified number of days.

D. Curing of the Samples

The curing of the specimens is the next step in which specimen are demoulded and are directly cured in the water for specified days of curing. The curing is done by the ponding method in which the specimens are placed inside water fully submerged. The normal portable water is used for the curing of the specimens. The specimens are to be placed by providing the proper space in which the water circulation for every specimen needs to be provided properly. The ponding method of curing is most effective method of curing and hence, utilised in the project.

IV. RESULTS AND DISCUSSIONS

The final results of the experiments which is conducted and presented in this chapter. The data of tests conducted on the concrete which is induced with the bottle caps as fibers and thus the comparision of the bottle caps induced concrete with respect to the normal concrete is determined and the optimum point where the strength varies is found out in this experimental work.

A. Compression test results

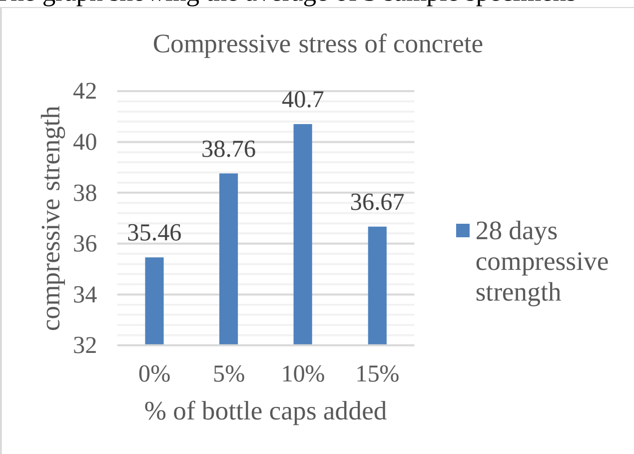
The outcomes obtained from the experiment conducted from the concrete with the variation in the ratios of the fibers added. The three ratios varying from 0%, 5%, 10%, and 15% the results showing the compressive stress on the concrete, the graph is plotted and shown in the diagrams as the strength varies and the peak is known where the strength gets varied. The compressive stress on concrete is determined.

The compressive stress results of the cubes of 3 ratios, 3 specimen’s average

% of bottle caps added	Dimensions	Failure load (KN)	Compressive strength (N/mm2)	
0%	150X150X150mm	816	36.26	35.46
	150X150X150mm	780	34.66	
	150X150X150mm	798	35.46	
5%	150X150X150mm	850	37.77	38.76
	150X150X150mm	897	39.86	
	150X150X150mm	870	38.66	
10%	150X150X150mm	897	39.86	40.70
	150X150X150mm	937	41.64	
	150X150X150mm	914	40.62	
15%	150X150X150mm	822	36.53	36.67
	150X150X150mm	804	35.73	
	150X150X150mm	850	37.77	

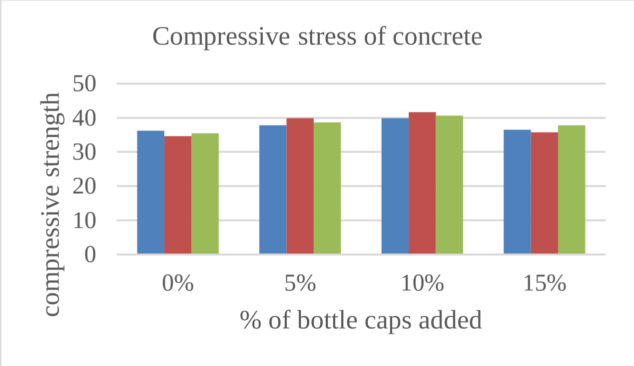
Table 1:

The graph showing the average of 3 sample specimens



Graph 1:

The graph showing the results of individual sample specimens



Graph 2:

B. *Observations*

By the results which are obtained from the tests conducted on concrete with the addition of the bottle caps as fibers increases the strength. The results obtained the concrete induced with 5%, 10% of the bottle caps as fibers and the strength gets increased but by addition of the 15% of the bottle caps as fibers the strength gradually decrease in strength is observed.

C. *Split Tensile Strength Tests Results*

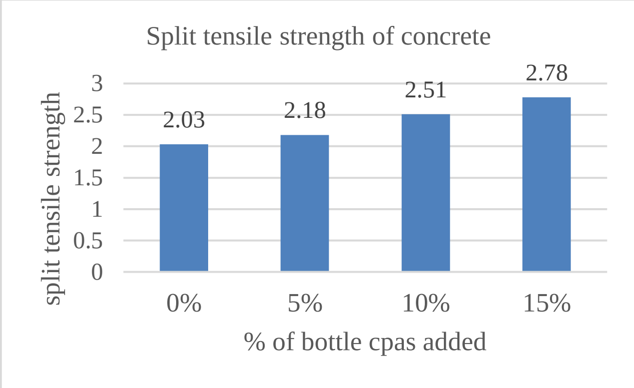
The split tensile strength results obtained from conducting the tests the results which shows the variation strength with respect to inclusion of bottle caps as fibers in the ratios of 0%, 5%, 10% and 15% with respect to the bottle caps added the corresponding strength is obtained and thus the comparision with the normal concrete is made and the difference is found in the results.

The tensile strength of concrete with 3 ratios, 3 specimen's average.

% of bottle caps added to the concrete	Dimensions	Failure load (KN)	Tensile strength (N/mm2)	
0%	150diaX300mm	137	1.93	2.03
	150diaX300mm	149	2.10	
	150diaX300mm	147	2.07	
5%	150diax300mm	121	1.71	2.18
	150diaX00mmm	165	2.33	
	150diaX300mm	178	2.51	
10%	150diaX300mm	160	2.26	2.51
	150diaX300mm	170	2.40	
	150diaX300mm	204	2.88	
15%	150diaX300mm	194	2.74	2.78
	150diaX300mm	195	2.75	
	150diaX300mm	202	2.85	

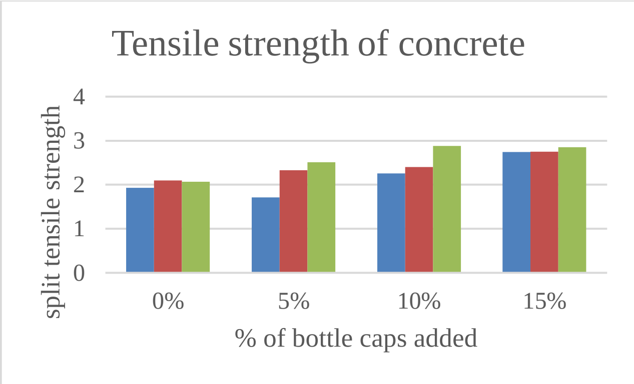
Table 2:

The graph showing average of 3 sample specimens.



Graph 3:

The graph showing the strength of individual samples.



Graph 4:

D. *Observations*

The results obtained from the tests which is conducted the concrete is casted in the cylinders form of the different ratios which are 0%, 5%, 10% and 15% are casted and thus after testing the cylinders by adding load at the constant rate the final breaking load is recorded and thus the tensile strength of concrete is found out thus by adding the concrete up to the 15% of the bottle caps as fibers with respect to the cement the strength is gradually increased.

E. *Flexural strength tests results*

The flexural load carrying capacity of the concrete is obtained by conducting the concrete in the beam and thus the beams are placed in the flexural testing machine and thus the two point load is applied over the bema in which the final breaking load of the beam is recorded and thus the flexural strength induced with the bottle caps as fibers is found out and thus compared with respect to the normal concrete and the difference is known.

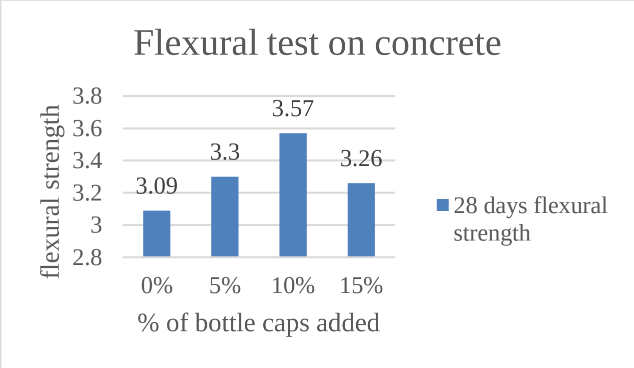
The test results of flexural strength with 3 ratios, 3 specimen's average.

% of bottle caps added the concrete	Dimensions	Failure load (KN)	Flexural strength (N/mm2)	
0%	500X100X100mm	19	3.5	3.09
	500X100X100mm	18	2.92	
	500X100X100mm	17.5	2.85	
5%	500X100X100mm	18.5	3.2	3.3
	500X100X100mm	18	2.92	
	500X100X100mm	19.5	3.78	

10%	500X100X100mm	22	4.25	3.57
	500X100X100mm	16	2.5	
	500X100X100mm	20	3.98	
15%	500X100X100mm	17	2.78	3.26
	500X100X100mm	19	3.5	
	500X100X100mm	19	3.5	

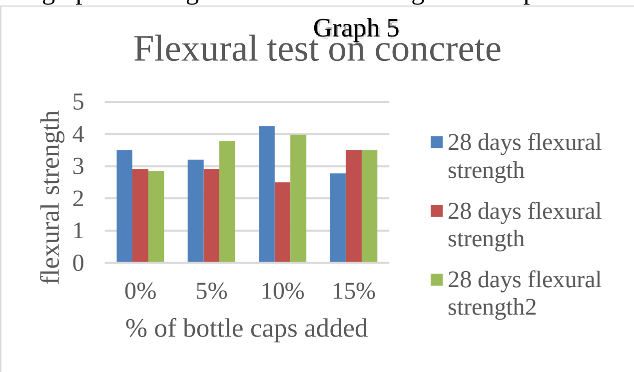
Table 3:

The graph showing the average of 3 sample specimens.



Graph 5:

The graph showing the individual strength of samples.



Graph 6:

F. *Observations*

The tests indicates the concrete which is casted in the beam with the bottle caps as fibers in which the flexural load carrying capacity of concrete is calculated in which the data indicates the concrete induced with the bottle caps as fibers has a greater strength compared to the normal concrete such that at the variation of 15 % of the bottle caps as fibers shows the decrease in strength and thus this observed result is obtained.

The each tests results shows the different ratios of fibers utilised in concrete and the strength parameters in which the overall results shows the usage of the bottle caps in the concrete increases the strength and thus provides the greater utilisation of the waste bottle caps and reusing them as the addition reinforcement in the concrete.

G. *SEM Analysis*

SEM analysis is the process of scanning the materials in a finely focused beam of electrons across the specimen and measures the signals resulting from the specimen interaction. The images from the SEM analysis obtained are monochrome since they reflect the rays resulting from the specimen. By the utilisation of the SEM analysis the concrete microstructure can be studied easily and helps in evaluating the supplementary cementitious materials, evaluation of concrete durability problems and prediction of service life by utilising the scanning electron microscopy. The images of topography is utilised to analyse the particle size, shape, surface, fracture surface are determined. The internal analysis of the materials and the characteristics can be easily analysed by the scanning electron microscopy.

The specimen is placed in the device and thus before placing the specimen the concrete specimen is heated under the lamp so that water content is clearly eliminated such that it should not affect the scanning of the specimen. The specimen are placed inside the machine and the cover is closed and such that the specimen number has to be selected and thus the scanning and viewing of the specimen is done by increasing the zoom in quality and thus the internal fibers and the materials utilised in the concrete are found out and observed and such that the images are collected and thus the analysing of the image can be done for further process.

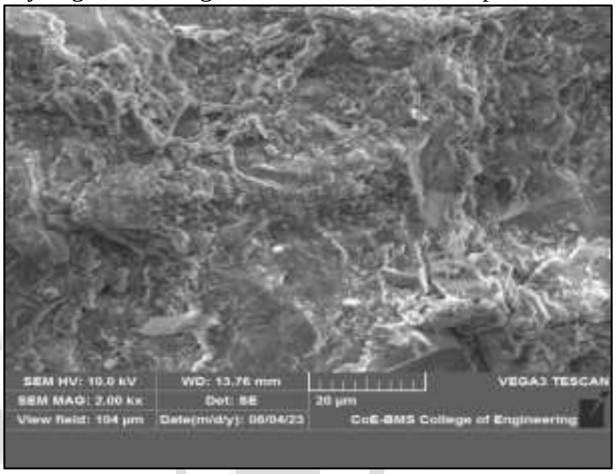


Fig. 3:

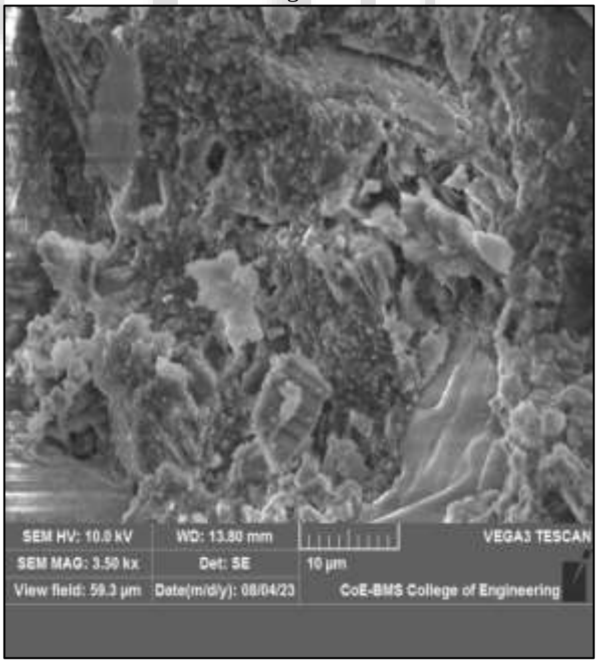


Fig. 4:

V. CONCLUSIONS

The research shows the concrete properties induced with the bottle caps as fibers in it. The characteristics properties of the concrete is greater due to addition of the bottle caps as a fibers in the concrete. Based on the tests which are conducted on samples after casting, the conclusions are obtained. The conclusions obtained from the experimental results are

1) The addition of the bottle caps as fibers increases the strength parameters of the concrete.
2) The compressive load carrying capacity induced with the bottle caps as fibers has provided greater strength but as the increase in the bottle caps as fibers the strength gradually decreases.
3) The split tensile load carrying of concrete increases with induction of bottle caps as fibers in which the experiment up to 15% the bottle caps are added and the strength is increased.
4) The flexural strength gets higher due to induction of the addition of the bottle caps up to 10% but after increasing the bottle caps as fibers to 15% the strength gradually decreased.
5) The results from the experiment conclude that the compressive, split tensile, flexural strength of the concrete induced with the bottle caps as fibers to 10% is greater than the nominal mix.
6) The availability of the bottle caps is very easy and since it is available in the waste form thus by utilising it as it is a steel caps it will increase the tensile properties and thus improves the strength parameters and the reduction in the waste can be achieved to some extent and can be reused.

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