REDUCING ENVIRONMENTAL IMPACT OF METAL BOTTLE CROWN CAPS BY REUSING THEM AS FIBERS IN CONCRETE

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Abstract - The paper presents the development of concrete using bottle crown caps as fibers and reducing the environmental impact of these in a effective manner. An attempt has been made in the present investigations to study the influence of soft drink bottle crown caps as a steel fiber in concrete at a dosage of 0%, 0.25%, 0.5%, 0.75%, 1%, 1.25% and 1.5% by volume of concrete with super plasticizer. Experimental investigations were done using M35 mix and tests were carried out as per recommended procedures by relevant codes. The study parameters of this investigation included compressive strength, split tensile strength and flexural strength of conventional and fibre reinforced concrete. The compressive strength, split tensile strength and flexural strength properties of the fibre reinforced concrete were studied and compared with that of the conventional concrete. The load deflection curve was observed as the fibre content increased in concrete. The comparison between with and without using soft drink bottle crown caps as steel fibers were studied to know its crack resistant behaviour. The paper concludes that a good percentage of crown caps can be used in concrete without undermining the strength of concrete and inevitably reducing its impact on the environment by a huge factor.

Keywords - Environment impact, Natural aggregate, soft drink bottle crown caps, fibre reinforced concrete, mix design, admixture, workability, Compressive strength, tensile strength, flexural strength, load v/s deflection.

I. INTRODUCTION

Bottle caps are often so small that it's easy to overlook the impact they have on the environment. If you drop one on the ground at the park or the beach, you may think it's not a big deal. But the Environmental Awareness Campaign found that "bottle crown caps are one of the top 10 items found during marine debris beach clean-ups and are the second most littered item after cigarette butts."
Recycling seems like a good option, but did you know that many cities don't accept caps for recycling?
There are many reasons for not accepting the bottle crown caps for recycling, which is a vast topic by itself and needs even more urgent attention. The crown caps have to be recycled.

There's no sense in sugar-coating it. Bottle caps are destructive to the environment. It is a fact that 67 million bottle crown caps are thrown away each day. While almost all of these caps originate from land based sources, they leak into the waterways and eventually into the oceans. These caps easily breakdown in the marine environment and are ingested by marine life and birds. The impact on oceans is devastating. The informal waste collection sector has no incentive to collect these caps as they have no value.

That's a staggering amount of waste considering only 10 percent of these bottle crown caps are ever recycled. Despite the good reputation recycling has, this practice is not always best for the ecosystem as it is labor-intensive, costly and burns natural resources. Also, just because you are throwing your used water bottles into the recycling bin, it does not necessarily mean the bottle crown caps are able to be recycled.
Therefore recycling and reusing these crown caps becomes an imminent reason in reducing their impact on the environment.
The other reason is that the mining, beneficiation and smelting of primary metal ores is inherently dirty and energy-intensive. Moreover, the lower the grade of ore, the dirtier and more energy intensive the recovery process is. And usually much of these crown caps are made from cheap metals which usually come from lower grade ores. It is much less easy to recover metal economically from cans, bottle caps, wire products, aluminum foil, fasteners (e.g. nails), razor blades, mattress springs and so forth. These tend to be mixed with other kinds of waste (household refuse) or to be scattered over the landscape as litter. Every ton of metal that is re-used, remanufactured or recycled — or avoided by dematerialization — replaces a ton that would otherwise have to be mined and smelted, with all of the intermediate energy and material requirements associated with those activities. Hence, validating the use of these crown caps as fibers in concrete is viable.

Concrete is generally 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 fibres is practiced. Disposal of Non-Biodegradable Materials is a serious problem. It creates environmental problems. Reusing is the best option to reduce the waste. These NBD materials are non-corrosive, resistant to chemical attack, light in weight, easy to handle. NBD materials – tin and steel. Studies conducted so far, proved that the short and discrete, small fibres can improve the flexural load carrying capacities and impact resistance for non-ferrous fibres.

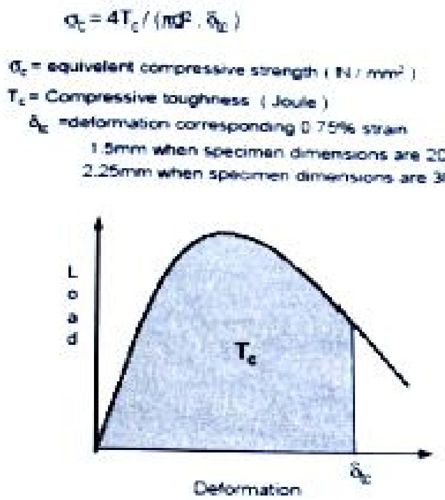
Soft Drink Bottle Caps As Steel Fibres

This research focuses on shredded soft drink bottle caps as steel fibres. Steel fibre length ranges from 1/4 to 3inches (1.5 to 75 mm) and aspect ratio ranges from 30 to 100.

Fig: Soft drink bottle Crown caps

BEHAVIOUR OF STEEL FIBRE REINFORCED CONCRETE UNDER COMPRESSION

Compressive strength is little influenced by steel fibre addition. However, the use of steel fibres the mode of failure of high strength concrete from an explosive brittle one to a more ductile one, again showing the increased toughness of SFRC and its ability to absorb energy under dynamic loading.



BEHAVIOUR OF STEEL FIBRE REINFORCED CONCRETE UNDER FLEXURE

In numerous investigations, it has been displayed that the flexure, shear, torsion, punching, dynamic impact behaviors of structural elements improved by the use of Steel Fibre Reinforced Concrete. The positive effects of SFRC on the flexure behavior of the structural elements are given as follows by Craig (1984).

- Increases moment capacity and cracking moment,
- Increase the ductility,
- Increases crack control,
- Increases rigidity,
- Preserves the structural integrity after beam exceeds the ultimate load.

Factors Affecting The Flexure Behaviour Of Steel Fibre Reinforced Concrete.

(A) Influence of Steel Fibre Volume Fraction

The increase in fiber fraction essentially provides the improvement in flexural strength and a stable post-crack behaviour. The bending capacity increases as the fibre volume fraction increases.

(B) Influence of Fibre Length

Longer the fibres with higher aspect ratios provide better performance in both strength increase and energy absorption as long as they can be mixed, placed, compacted and finished properly. Since hooked-end fibres provide good anchorage, an increase in aspect ratio of hooked-end fibres has less influence compared with straight fibres.

(C) Influence of Fibre Geometry

Three different fibre geometries, namely hooked-end fibres, corrugated fibres and deformed-end fibres with equal length are studied on the flexural behaviour of Steel Fibre Reinforced Concrete by Gopalaratnam et al. (1991). According to test results, concrete with hooked-end fibres have higher tensile strength and post-crack response than the other two types. The drop after the first peak is much more pronounced for corrugated and deformed-end fibres.

II. OBJECTIVES OF THE PRESENT STUDY

- Effect of fiber dosage on 28day – Compressive, Flexural and Split tensile strengths.
- Optimum dosage of fibers for the improvement of flexural and split-tensile strength.
- Effect of fiber dosage on the relation between compressive strength, split tensile strength and flexural strength of fiber reinforced concrete.

III. METHODOLOGY OF STUDY

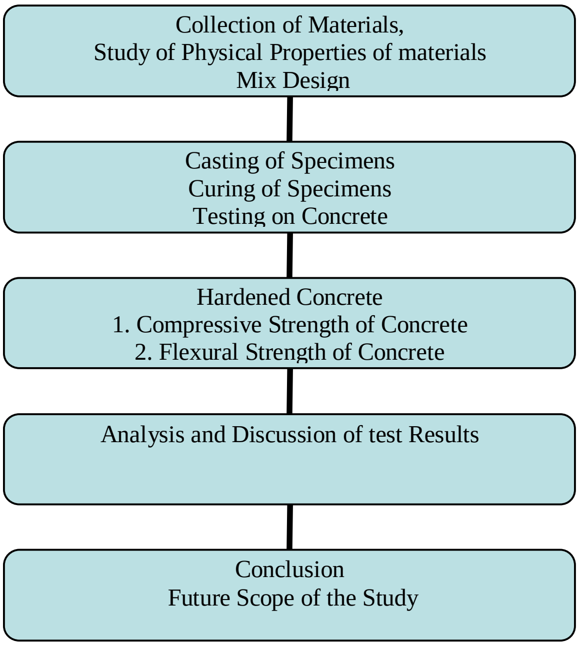
A. Collection of Materials

The materials were collected from nearby retail shops and stores where the bottle crown caps were available in plenty. The other materials for the concrete mix were procured from the usual sources.

B. Material Testing

S.No	Material	Property details	
1.	Cement	Grade	43-OPC
		Consistency	34%
		Specific gravity	3.15
		Fineness	2%
2.	Natural sand	Grading Zone	Zone II
		Specific gravity	2.70
		Fineness	2.43%
3.	Glass powder	Specific gravity	2.66
		Fineness	3.36%
4.	Coarse Aggregate	Specific gravity	2.60
		Fineness	7.14%
5.	Water	Type	Potable

Sl No	Particulars	Description
1	Brand	Bottle caps (tin free steel)
2	Length	10mm
3	Thickness	3mm
4	Fibre	Deformed wire type usually flattened



IV. EXPERIMENTAL INVESTIGATION

The most common of all tests on hardened concrete is the compressive strength test. This is partly because it is easy to make, and partly because many though not all, of the desirable characteristics of concrete are qualitatively related to its strength, but mainly because of the intrinsic importance of the compressive strength of concrete in construction.

A. Mix Design

Concrete Mix	M35
Cement (kg)	400
Fine aggregate (Kg)	642
Coarse aggregate (Kg)	1165
Water (liters)	160
Volume of plasticizer by weight of cement in %	0.4

B. Specimen Nomenclature

The shredded crown cap fibers were added in percentages as follows; 0% (control specimen), 0.25%, 0.5%, 0.75%, 1.0%, 1.25%, 1.5%.

% fiber proportion	Specimen Nomenclature	Compressive strength (No. of Moulds)	Split tensile (No. of Moulds)	Flexure (No. of Moulds)
0%	SFRC-0%	3	3	3
0.25%	SFRC-0.25%	3	3	3
0.50%	SFRC-0.5%	3	3	3
0.75%	SFRC-0.75%	3	3	3
1.00%	SFRC-1.0%	3	3	3
1.25%	SFRC-1.25%	3	3	3
1.50%	SFRC-1.5%	3	3	3

Fig: Beam Specimen

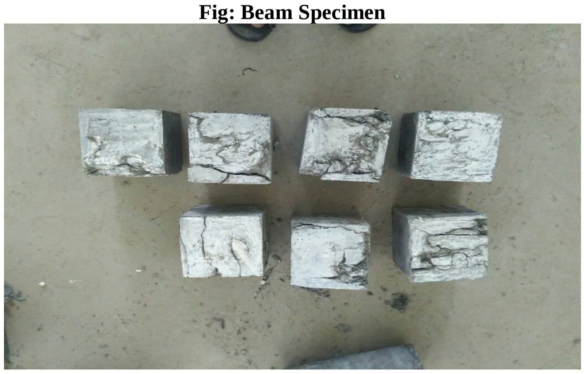
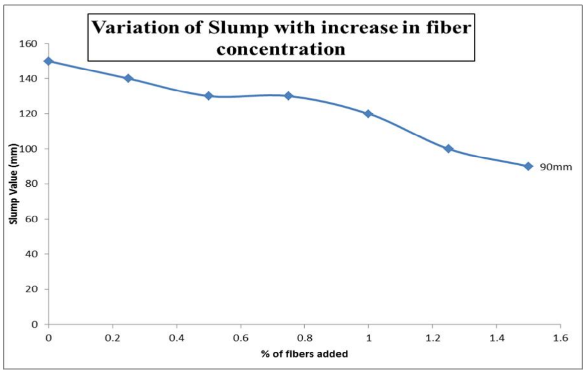


Fig: Cube Specimens

Fig: Cylindrical specimens

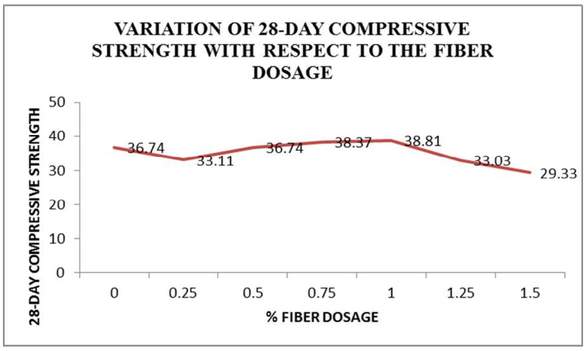
V. EXPERIMENTAL INVESTIGATION

A. Effect of Fibers on Slump



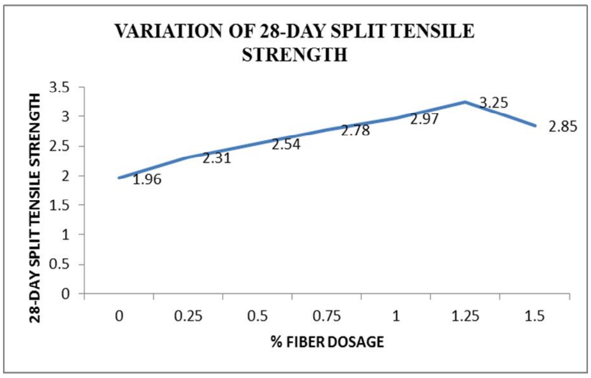
- The fibers were distributed in the concrete mix during the wet state.
- The fibers have the inherent quality of forming lumps and balls due to interlocking effect.
- So as the percentage of fibers increase the slump reduces, the optimum percentage for the slump is hence selected based on the requirement.

B. Effect of Fibers on Compressive Strength of Concrete



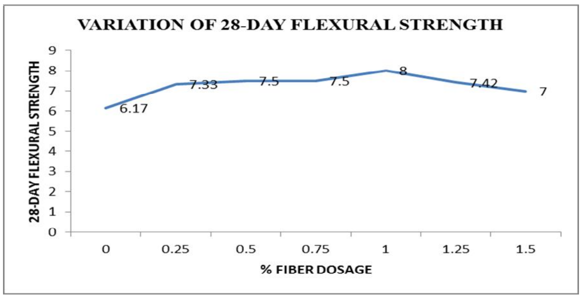
- The fibers when added to the concrete mix reduce the amount of cement in the given volume of the specimen.
- This decrease in the compressive strength has to be compensated by the poisson effect of the fibers when loaded in compression.
- The optimum dosage for the above effect to be fully included is 1% as per the experimental data.
- Beyond the optimum percentage the strength reduces but not drastically.

C. Effect of Fibers on Split Tensile Strength of Concrete



- The fibers extensively increase the Split tensile strength of the concrete since it inherently increases the materials resistance to the Poisson's effect.
- The elastic strength of the fibers is more and therefore had tremendous effect on the concrete.
- The bond strength between the concrete and the fibers are also more as mentioned in the physical characteristics of the fibers through which we could conclude that it supports the strength if the concrete.
- The optimum percentage of the fibers is 1.25% for the positive effect of fibers to be maximum.

D. Effect of Fibers on Flexural Strength of Concrete



- The flexural resistance of the concrete is increased by the inclusion of fibers, as the aspect ratio of fibers and the inherent flexural property of the fibers are also more.
- Compared to the split tensile strength capacity of the fiber the flexural capacity of the fiber has drastic improvement by which we could conclude that the orientation of the fibers have played a major role.
- The optimum dosage of fibers for flexural capacity to be maximum is 1%.

CONCLUSIONS

- The above strength tests on the concrete with the inclusion of fibers conclude that there is an effective increase in values with the addition of the fibers up to an optimum value.
- The aspect ratio selected for the fibers such that the crown caps can be cut and managed is good enough as per the literature review.
- The optimum percentage of the fibers to be added by weight of cement is 1% considering the effect of fibers on Slump, Compressive strength, Split Tensile strength and Flexural strength of concrete.
- The major conclusion here is that the fibers can be used with concrete without causing an detrimental effect to concrete.
- The inclusion of these crown caps is a positive effect which means that disposing the fibers is not a problem now and the environmental impact of the bottle crown caps has been reduced.

FUTURE SCOPE

- The collection of the fibers would pose a major problem now, so the collection methods has to be properly analyzed and studied.
- A comprehensive study on the optimum aspect ratio of the fibers need to be carried out.
- The combination of different types of materials available in the bottle caps can be studied which makes the work easier and sorting for the material of the bottle caps would not pose a problem.

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