Utilization of Soft Drink Tins as Fiber Reinforcement in concrete

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Muhammad Akram Akhund[1], Abdullah Sannd[2], Uroosa Memon[3], Shamotra Jai Oad[4]

[1]*PhD. Scholar, Civil Engineering Department, Mehran UET, 76020. Jamshoro, Pakistan.*
[2]*Professor, Civil Engineering Department, Quaid-e-Awam UET, 67480, Nawabshah, Pakistan.*
[3]*Lecturer. Isra University, 66001, Hyderabad, Pakistan.*
[4]*M.E Student, Construction Management Department, Mehran UET, 76020, Jamshoro, Pakistan*

Abstract: It has been recognized that the addition of small, closely spaced and uniformly dispersed fibers to concrete would act as crack arrester and would substantially improve its static and dynamic properties. In this research, soft drink tins were used as fiber reinforcement in concrete to produce fiber reinforcement concrete (FRC). Some work was carried out in the past to observe the effect of fibers (soft drink tins) in concrete on compressive strength as well as workability of concrete. This study aimed to determine the effect of soft drink tins as used fiber reinforcement on compressive strength of concrete. There were 30 cubes in total were casted by utilizing this ratio 1: 1.69: 3.15 at 0.54 w/c ratios by using mix design method. The cubes were casted using a proportion of fibers 1%, 2% and 3% by weight of cement using ½", 1" and 1 ½" long strip respectively. Results shows that with the increase in the percentage and size of strips in concrete, the workability of concrete is decreased and the compressive strength is significantly increased in fiber made mix concrete. Maximum compressive strength, i.e. 33% more than control mix concrete, is obtained using 1.5" long with 3% of fiber strips.

Keywords: *Fiber Reinforcement Concrete; Workability and Compressive Strength*

1. Introduction

Due to growing needs of performance and durability of concrete there has been a continuous search for upgrading properties of concrete, for example, concrete is reinforced as longitudinal bars and in the form of pieces called fibers. Fiber reinforced concrete (FRC) is defined as a composite material which is made up of Portland cement, aggregate, and incorporating discrete fibers. Various types of fibers have been used so far such as, steel, glass, synthetic and un-synthetic (natural) fibers. Still researching is underlying to introduce some new and better ones. The fibers can be introduced as reinforcement to increase the mechanical properties of concrete [1]. Fibers inter lock and entangle around aggregate particles and considerably reduce the workability, while mixing it becomes more cohesive and less prone to segregation. The additions of fibers make the plain concrete more versatile and more competitive as a construction material.

Inclusion of fibers changes the performance of concrete, Some fibers have high value of elastic modulus therefore they contribute in improving many of the properties like impact resistance, flexural strength, tensile strength, compressive strength, fatigue resistance, ductility, shear strength and resistance against wear and abrasion. Due to this improvement in the performance fiber reinforced concrete has found special applications in hydraulic structures, airfield pavements, bridge decks, heavy duty floor (Industrial floors) and tunnel lining [2,3]. Nowadays waste material is being utilized in concrete as fiber to make fiber reinforcement concrete, waste and disposable material damages the environment and it is the problematic to environmental engineers. Many researchers are working on such waste materials for increasing the strength of concrete structures and finding cost effective materials.

G.C. Behera1, R.K, Behera [4] studied the influence of addition of waste materials like soft drink bottle caps from workshop at a dosage of 0.25%, 0.5% and 1.0%, of the total weight of concrete as fibers. In this study caps of tins were designed in strips and each strip size was 3mm in width and 10mm in length. The concluded that increase in compressive strength is not prominent up to 1.0 % addition bottle cap fiber. Split tensile and flexural strength of 1.0 % bottle cap fiber concrete increase up to 12.59% and 16.96 % more than plain concrete(without bottle cap fiber) respectively.

Dora Foti [5] studied on the use of recycled waste polyethylene terephthalate (PET) bottles fibers for the reinforcement of concrete. The fiber has been obtained by simply cutting bottles and used as discrete reinforcement of specimens and little beams in substitution of steel bars. The obtained results were very useful, majority of this is in adherence between PET and concrete, which signifies the usage of fibers material in form of flat or rounded bars in structural reinforcement.

G.Murali et al [6] investigated to study the influence of crumpled steel fiber concrete at a dosage of 0.8 % volume of concrete and found that the compressive, split tensile and flexural strength of fiber reinforced concrete is increased by 32.14%, 52.38%, 12.68% respectively when compared to the conventional concrete.

G.Murali, C.M.Vivek Vardhan et al [7] performed the experimental investigation on fiber reinforced concrete using waste materials like lathe waste, soft drink bottle

Corresponding author's email.akhund42@gmail.com

caps, empty waste tins, waste steel powder from workshop at a dosage of 1% of the total weight of concrete as fibers. The lathe waste, empty tins, soft drink bottle caps were deformed into the rectangular strips of 3mm width and 10mm length. The results were compared with conventional concrete it was observed that concrete blocks incorporated with steel powder increased its compressive strength by 41.25% and tensile strength by 40.81%. Soft drink bottle caps reinforced blocks exhibited an increase in flexural strength of concrete by 25.88%.

Fernando Fraternali et al [8] worked out on the different parameters, such as mechanical strength; thermal resistance and ductility of RPETFRC in comparison with plain concrete were improved. It was also observed from literature review that the ameliorate results of compressive strength and fracture toughness obtained from RPETFRC which is more useful in polypropylene fiber reinforced concrete. In this research the soft drink tins are utilized and used to reinforce the concrete. The recycling and bio-grade of steel waste fiber material is difficult so it's an environmental issue. Now, much more importance is given for 3R's (Reduce, Reuse and Recycle). Preservation of environment and conservation of rapidly diminishing natural resources should be the essence of sustainable development. Soft drink tins are the substitute for fibers and added to enhance the mechanical properties of concrete, including compressive strength, workability and density. Soft drink tin fibers are used in different percentages and sizes as 1%, 2%, 3% and ½", 1",1 ½" respectively, to make fiber reinforced concrete.

2. Material

2.1 Cement

Ordinary Portland cement (OPC) named as the falcon cement was used in this research**.** Physical properties of cement are shown in Table. 1.

Table.1. Cement properties

Property	Value
Specific gravity	3.14
Fineness (m^2/Kg)	225
Initial setting time	40
Final Setting time	138
Standard Consistency (%)	27
Compressive strength (MPa)	44

2.2 Aggregates

Fine and Coarse aggregates were obtained from Bolhari and Nooriabad near to Karachi respectively. The fine aggregate were sieved from 4.75mm sieve and confirmed the zone-III and 10mm coarse aggregate confirmed the BS-882. Properties of aggregates are given in Table. 2.

Table.2. Aggregate properties

Properties	Aggregates	
	Fine aggregate	Coarse aggregate
Specific gravity	2.61	2.66
Fitness Modulus	2.49	6.94
Water Absorption (% age)	1.69	1.38
Unit weight (lb/ft$^{3)}$	102.47	97.51

2.3 Soft drink tins as fiber

The metallic waste such as soft drink tins obtained from various sources. The top and bottom cover of the tin was removed by cutting them by mechanical way. After removal of covers the body tins come in rectangular shape and they were thoroughly washed in clean water and dried properly and with the wire brush they were scratched so that the proper bond between the strip and concrete takes place, then the strips was cut in different sizes as of ½"x ½", ½"x 1", ½"x 1 ½". These fibers are added into the concrete with 1%, 2%, and 3% by weight of cement.

2.4 Water

In this research drinking water of the city of Nawabshah, Pakistan was used to prepare and curing the concrete specimens.

3. Design method for study

Concrete mix design was aimed for 30N/mm^2 at 28 days as per British DoE method for each case. Few trials were carried to check the mix design for the required strength; the ratio was used as 1:1.69:3.15 at 0.54 w/c ratio. The workability test by the slump cone method was conducted on freshly prepared concrete. In this research the 30 cubes of size 4"x4"x4" were prepared using the standard moulds to compute the compressive strength of concrete. Among 30 cubes, 3 cubes were made with control concrete, 27 cubes were made of fiber reinforced concrete, among these 27 cubes, 9 cubes were made using 1% of fiber, 9 cubes using 2% fiber and 9 cubes using 3% of fiber with three different sizes as ½"x ½", ½"x 1", ½"x 1 ½" of strips at each size three numbers of cubes were prepared. After casting the cubes were demolded after 24 hours and kept in water tank for 28 days curing. After proper 28 days curing of all 30 cubes, they were tested for compressive strength in Universal Testing Machine (UTM). Figure 1, shows the spreading of soft drink tins fibers.

Figure.1. Soft drink tins fiber added to concrete

Specimens cast details for investigation purpose are listed in Table. 3.

Table.3. Details of specimen

No.	Types of mix (Size & Percentage)	Number of cubes cast	Total number of cubes cast
1.	Control mix (C.M)	3	3
2.	0.5”and 1% 0.5” and 2% 0.5” and 3%	3 3 3	9
3.	1” and 1% 1” and 2% 1” and 3%	3 3 3	9
4.	1.5” and 1% 1.5” and 2% 1.5” and 3%	3 3 3	9

4. Experimental results and discussion

The total evaluated results are organized in tables form, whereas comparative analysis has been display in form of graphs and bar charts. The experimental results are determined by taking the average means of three casted cubes for tested purpose to found the compressive strength of these casted specimens. The evaluated results are examine as under 4 .1.

4.1 Workability

The workability of control and fiber made mixes was computed by the slump cone test method. The slump test is widely used in the World at construction site. Workability of concrete does not measure by using slump test, but according to ACI 116R90, this test is useful to measure consistency of concrete and also change in uniformity of mix in proposed proportions [2, 9]. The workability test results of all concrete mixes are summarized in Table: 4. The results shows that the slump of fiber made mixes is decreasing than control mix with the increase in size and percentage of fiber used, workability of fiber made mixes is decreasing dramatically due to non-uniformly distributed fibers, fibers inter lock and entangle around aggregate particles.

Fig: 2 to Fig: 4, shows the graphical representation of 0.5” to 1.5” size fiber with 1%, 2%, 3% of fiber by weight of cement. It clearly shows with the increase in the dosage of percentage the slump decreases than a control mix slump. Fig: 5 gives the comparison of all mixes at various size of strips, we compare the effect of size and percentage fiber used that significantly increasing the size and percentage of fiber 0.5” to 1.5” and 1% to 3% respectively the slump values are decreasing than control mix. The higher percentage and size of strip the lowest is the slump value.

Table.4. Slumps test results

No.	Mix design ratio	W/C Ratio	Types of mix (Size & Percentage)	Slump Values (mm)
1.	1:1.6:3.15	0.54	Control mix	18
2.	1:1.69:3.15		0.5”size 1% fiber mix	17
			0.5” size 2% fiber mix	15
			0.5” size 3% fiber mix	6
3.	1:1.69:3.15		1” size 1% fiber mix	16
			1” size 2% fiber mix	13
			1” size 3% fiber mix	5
4.	1:1.69:3.15		1.5” size 1% fiber mix	12
			1.5” size 2% fiber mix	7
			1.5” size 3% fiber mix	5

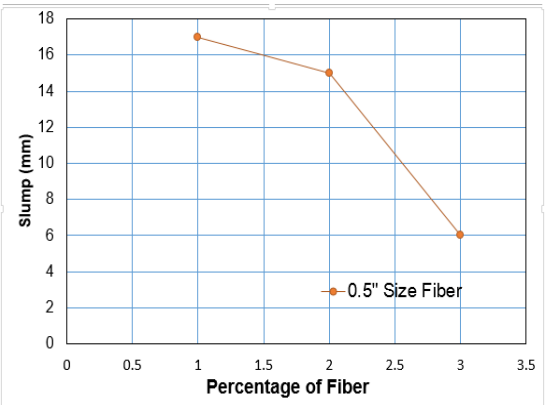

Figure.2. Slump (mm) VS percentage of fiber with 0.5”size of strips``

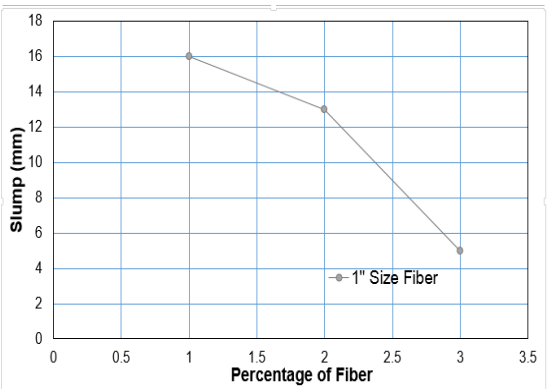

Figure.3. Slump (mm) VS percentage of fiber with 1”size of strips

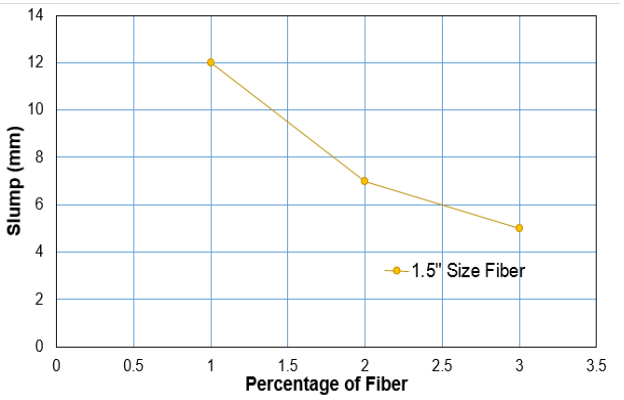

Figure.4. Slump (mm) VS percentage of fiber with 1.5"size of strips

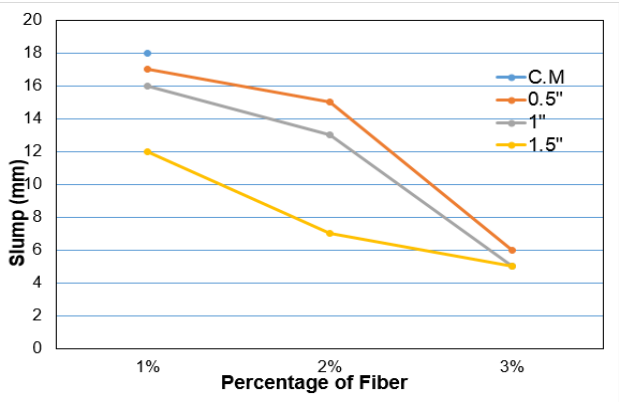

Figure.5.Comparison between slump (mm) VS percentage fiber of CM and fiber mixes with various size of strips

4.2 Compressive strength

Compressive strength is the measured parameter which influences other properties of concrete. Cubes were tested for compressive strength in UTM. The compressive strength test results of all the concrete cubes are summarized in Table 5, which shows the strength of all fiber made mixes over control mix, whereas their graphical presentation is shown in Fig: 6 to Fig: 9.

Table.5. Compressive strength of test results

No.	Types of mix (Size & Percentage)	Compressive Strength (MPa) at 28 days	Density (Kg/m^3)
1.	Control mix	17.6	2399
2.	0.5" size and 1% fiber mix	18.8	2377
3.	0.5" size and 2% fiber mix	19.94	2381
4.	0.5" size and 3% fiber mix	21.20	2335
5.	1" size and 1% fiber mix	22.23	2377
6.	1" size and 2% fiber mix	23.11	2380
7.	1" size and 3% fiber mix	23.80	2430
8.	1.5" size and 1% fiber mix	25.00	2386
9	1.5" size and 2% fiber mix	25.90	2383
10.	1.5" size and 3% fiber mix	26.31	2402

The compressive strength made by fiber made mixes, shows stronger effect than controlled concrete mix. It was observed that by increasing the size and percentage of fiber by weight of cement, the compressive strength significantly increases. This may be due to the fact that the failure of plain concrete is caused by mortar (sand + cement) failure. The bond between mortars with fiber in fiber reinforced concrete is stronger than that of plain concrete.

Fig: 6 to Fig: 8, shows that by adding 0.5" to 1.5" size strips with 1%, 2%, 3% fiber the compressive strength increases by increasing the percentage of fiber at each size. Fig: 9 gives the graphical representation of strength comparison of all mixes at various sizes which shows by increasing size from ½" to 1" and using the same percentage of fiber as 1%, 2%, 3% the strength results increasing than ½" size fiber used, similarly when we increase the size of fiber from 1" to 1.5" and keeping same percentage of fiber it shows strong effect than ½" and 1" size strip used, and Fig: 9 also shows that each size of strip with increase in the percentage of fiber shows the increase in the strength than control concrete mix results. Compressive strength of fiber mixes over control mix was found to be increased by 17%, 26% and 33% using 0.5", 1" and 1.5" long strips with fiber used 3% by weight of cement respectively.

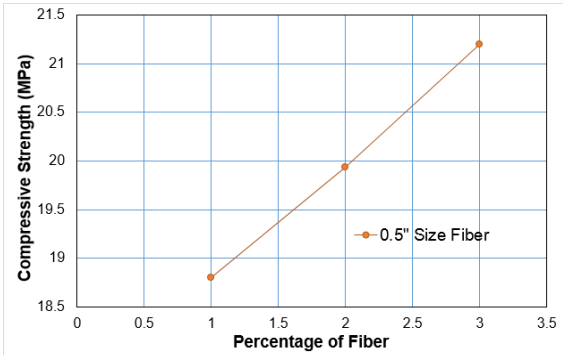

Figure.6. Compressive strength (MPa) VS percentage of fiber with 0.5"Size of strips

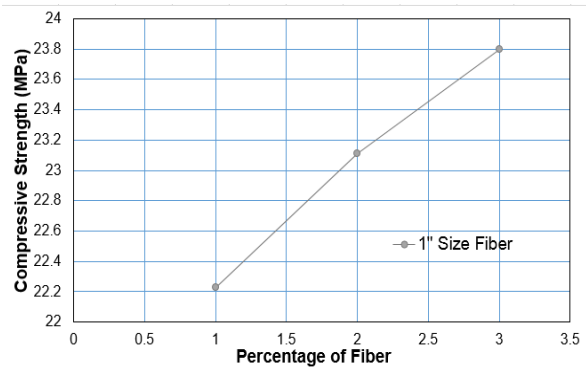

Figure.7. Compressive strength (MPa) VS percentage of fiber with 1"Size of strips

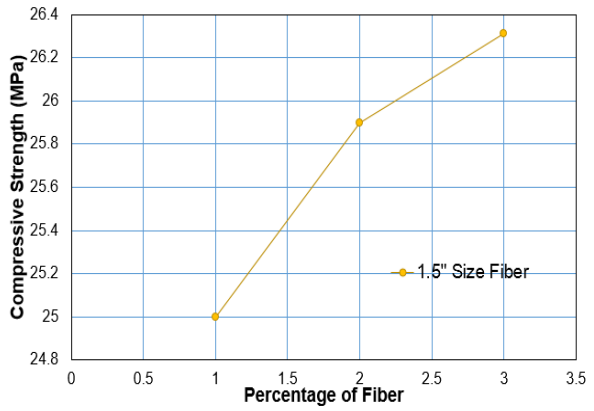

Figure.8. Compressive strength (MPa) VS percentage of fiber with 1.5"Size of strips

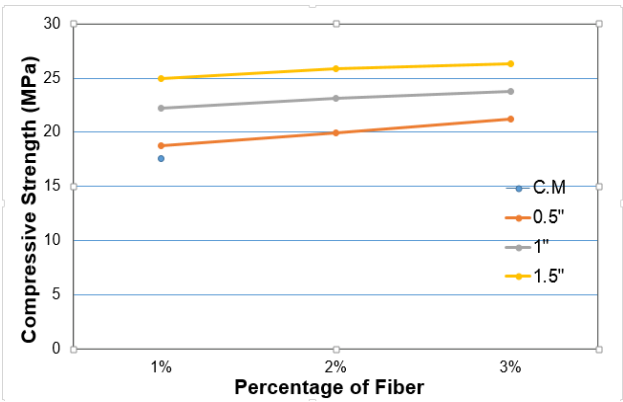

Figure.9. Comparison between compressive strength (MPa) VS percentage fiber of CM and fiber mixes with various size of strips

4.3 Unit Weight

Table:5 summarized the average values of unit weight or density (Kg/m^3) of all the mixes determined at the time of the testing of the specimens for compressive strength. The unit weight of fiber made mixes was decreasing and increasing than controlled concrete mixes. The Fiber made concrete mixes have mean unit weight value is 2383kg/m^{3}and controlled mix is 2399kg/m^3, so during design of fiber reinforced concrete only unit weight is not consider a main constraint for addition of soft drink tins strips.

5. Conclusion

In this research , soft drink tins are utilized in concrete as fiber to make fiber reinforcement concrete. Soft drink tins are the substitute for fiber and added to enhance the mechanical properties of concrete, including workability, compressive strength and density. Soft drink tins fiber are used in different percentages and sizes as 1%, 2%, 3% and ½", 1",1 ½" respectively, to make fiber reinforced concrete. Based on the experimental study conducted and the results presented here, following conclusion can be drawn.

1. Workability of fiber reinforced concrete mixes was decreased gradually with increase in the percentage and size of the fiber over control concrete mix.
2. Workability of 0.5" size and 3% of the fiber was lower than that of 1% and 2% of the same size, and with the increase in size of fiber from 0.5" to 1.5" and percentage from 1% to 3% it decreases simultaneously.
3. Fiber Reinforced concrete mixes can give better compressive strength than that of control concrete mix at 28 days.
4. With the increase in the percentage and sizes of fiber the compressive strength increases of fiber made concrete mixes over control concrete mix.
5. For higher size (1.5") and a greater percentage of the fiber (3%) can give better compressive strength than that of lower size of strips (0.5" and 1") and lower percentage of the fiber (1% and 2%).
6. In general experimental study shows that with the increase in size and percentage of the fiber the workability of fiber reinforced concrete mixes decreases and the compressive strength increased than control concrete mix.

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About authors

Engr. Muhammad Akram Akhund, got Bachelor in Engineering in 2012 from Quaid-e-Awam University of Engineering, Science and Technology Nawabshah. He did his Master of Engineering in the field of Construction Management from Mehran University of Engineering Technology Jamshoro in 2016. His research title of master study was "Developing a Knowledge Based Expert System for Controlling Time Overrun and Cost Overrun in Construction Projects of Pakistan Construction Industry." Now he is doing Doctor of Philosophy (PhD) in Construction Management from MUET, Jamshoro. His research interests' areas are Construction Cost Management, Construction delay, Construction Waste Management, Sustainable Construction Management, Project Management and Construction Management etc.

Prof. Dr. Abdullah Saand, got B.E (Civil Engineering), M.E (Structural Engineering) from MUET Jamshoro and PhD in Polymer Modified Mortar from UTM, Malaysia. He is working a Professor at department of civil engineering QUEST Nawabshah Sindh Pakistan additionally he is Dean of Quality Enhancement Cell at the same University Dr. Abdullah Saand had very enormous teaching and research experience in Polymer Modified Concrete/Mortar, Cement Replacement Material, Fiber Reinforcement Concrete, Self-Compacted Concrete. Recently he has produces Ph.Ds at the QUEST University. At present Dr. Saand is supervising several post graduate students of ME and Ph.D level.

Engr. Uroosa Memon, has been working as a Lecturer in Civil Engineering Department of Isra University, Campus of Hyderabad since 2016. Her did Master of Engineering in the field of Structural Engineering from MUET Jamshoro in 2016. She did her B.E in Civil Engineering in 2012 from QUEST, Nawabshah. Her research interests are Fiber Reinforcement Concrete, Self-Compacted Concrete and Air Entraining Agents concrete. her research title in M.E was "Effect of Air Entraining Admixture on the Strength of Cement Concrete."

Engr. Shamotra Jai Oad, has working as a Sub-Engineer in Works and Service Department of Sindh and she is doing Master of Engineering in the Field of Hydraulics and Irrigation from MUET Jamshoro. Her did B.E in Civil Engineering from QUEST Nawabshah in 2012.