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Mechanical Behavior of Concrete Reinforced with Waste Aluminium Strips

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Abstract

The main objective of this research work is to investigate the influence of the addition of waste materials, like aluminium waste material, Soft Drink Tin Fibers (SDTF) or soft tins to improve mechanical properties of concrete and also study the strength behavior of concrete, such as flexural strength and indirect or split tensile strength. It has been acknowledged that the use of fibers in concrete has considerable effects to improve strength parameters and characteristics of concrete. In this research work, similar efforts are made to present the effects of soft tin fibers or aluminium waste material as a reinforcing material in concrete and to assess the mechanical behavior of concrete. Particularly, this research work aimed to investigate experimentally the effect of soft drink tins on tensile (cylinder splitting tensile strength) and flexural strength. Soft tin fibers of 25.4 × 5 × 0.5 mm in size were used and added from 1 to 5% by the weight of cement with the design mix of 1:1.624:2.760 at 0.50 w/c ratio. Therefore, 6 batches (every batch contained 3 prisms and 3 cylinders) were prepared and cast for evaluation of tensile and flexural strength. One batch was cast without inclusion of fibers (controlled batch) and remaining 5 batches were cast with the addition of fibers using 1, 2, 3, 4, and 5% respectively. It was revealed from obtained results that split tensile strength and flexural strength of specimen increases as compared to controlled batch up to 4% addition of fibers. Moreover, beyond 4% soft drink tin fiber level, strength begins to fall down. Thus, it can be suggested that mechanical properties of concrete can be enhanced by 4% of soft drink tin fibers. Moreover, in this study, soft drink tin fibers (SDTF) or aluminium waste are used as the application of utilization of waste materials as a partial construction material and also on another side it controls the solid waste and environmental pollution.

Keywords: Fiber-reinforced Concrete; Mechanical Behaviour; Soft Drink Tin Fibers (SDTF); Aluminium Waste; Flexural Strength; Indirect Tensile Strength.

1. Introduction

Concrete is considered a very important and versatile material extensively used in construction industry owing to various benefits. It is viable, robust and cost-effective as compared to other conventional building materials [1]. Flexural and tensile strength of concrete is low; however, it is very strong in compressive strength as concrete is brittle in nature [2]. Thus, in order to improve the flexural strength and tensile strength, various types of fibers are mostly used as reinforcement [3]. As a matter of fact, steel helps to the carbon dioxide CO_2 emissions in atmosphere, which enhances to global warming [4]. In this regard, there is need of an hour for sustainable, green or fiber reinforced

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concrete to be used from waste materials, that must be eco-friendly concrete. Fiber reinforced concrete is the concrete that contains fibrous material that increases its structural performance. It comprises short discrete fibers that are consistently distributed and randomly oriented. Furthermore, the fibers obtained from waste materials of the environment are utilized in order to protect natural resources and reduce environmental pollution. The idea of reinforcing concrete by the inclusion of fiber was first advised by Portar in 1910.

Moreover, the works of Romualdi, and Batson (1963) on steel fibers in concrete, and of Biryukovich on the glass fiber reinforced concrete paved a new concept in this subject [5]. The concept of utilizing fibers as reinforcement material is not a modern concept, fibers have been used as reinforcement since traditional and ancient times [6]. A recent advancement has been made in this subject; waste materials have been used in concrete to improve one of the strength behaviors of the concrete by incorporating fibers in concrete [7]. Inclusion of fibers improves the performance of concrete. Most of the fibers have high value of elastic modulus and other properties which might have a positive influence on concrete properties. Thus, fibers contribute in improving many of the properties like, flexural strength, tensile strength, compressive strength, and others. At the present time, waste material is abundantly being utilized in concrete as one other fibers to make fiber reinforcement concrete. Many researchers are struggling on the usage of such waste materials for increasing the strength of concrete structures and ultimately finding the cost-effective and eco-friendly materials. Moreover, research into novel fiber-reinforced concretes continues at present [8]. Thus, in this study soft tin fibers or aluminium waste fibers are used as reinforcing material to enhance mechanical properties of concrete [9, 10].

In recent times, similar efforts have been made to improve strength parameters by using fibers [11]. They investigated the compressive strength by using soft tin fibers and results were obtained satisfactory, moreover, workability was also investigated by using fibers. However, other strength parameters such as tensile and flexural could also be determined by using the same fibers. Therefore, this study aimed to investigate tensile and flexural strength parameters to improve overall mechanical performance of concrete. As concrete is very weak in tension, it is quite essential to improve the weaker part of concrete. Tensile strength of concrete is considered as 10% of its compressive strength and flexural strength is comparatively low. In this regard, few studies are available on the use of soft tin fibers or aluminium can fibers to determine strength parameters [12, 13]. Authors utilize aluminium can fibers by using different fiber ratios by the weight of cement, results revealed that the tensile and flexural strength is improved with increasing fibers while compressive strength is adversely affected. It was observed from the study that for 3% addition of aluminium can fibers tensile and flexural strength increase considerably. Similar work was also performed on the use of soft drink can fibers with different dosage of fibers by the volume of concrete [14, 15]. It was found from the study that the tensile strength is increased by 1.5% and the compressive strength by 0.5%, however, with the increasing dosage of fibers, the compressive strength slightly decreases.

In order to improve low tensile strength and flexural strength, inclusion of fibers in concrete have been a major concern of the researchers. Moreover, Influence of addition of fibers on concrete have been studied and investigated in detail and use of waste materials and aluminium can fibers are being used abundantly as a reinforcing material and partial construction material in today’s construction industries to make concrete robust and cost-effective material [16, 17]. Large amounts of solid waste materials gather every year in every country. Nowadays resource efficiency is being increased as the utmost important concern in construction industries [18]. Thus, use of waste materials and secondary materials are being emphasised in the production and today’s construction industries. With the increasing demand of cement for concrete, a huge volume of energy is required. It is reported that about 7% of CO_2 is released to the atmosphere owing to generation of cement in production industries [19]. Detrimental properties of concrete on the environment can be eliminated by making durable concrete by using these secondary and waste materials. In our country Pakistan, there is a huge number of construction practices which are growing at a rapid rate. Such an enormous scale building and construction activities demand a huge amount of capital and other sources. Building and other construction materials contribute near around 75% of the cost out of total cost. Thus, there is dire need of the replacement of expensive, and conventional construction materials by creative, innovative cost-effective substitute construction materials. Hence, in this study use of soft drink can fiber or aluminium waste fiber is used as the waste and secondary materials generated as a result of the environmental waste. This can have a good influence on tensile and flexural strength parameters. Results revealed that there is a positive influence of addition of fibers in improving mechanical performance of the concrete in terms of tensile and flexural strength parameters.

Soft drink tin fiber or aluminium can fiber is considered as one of the waste materials or secondary materials, this could have a promising future in the construction sector. It is a waste material obtained after the use of beverage cans in which beverage or liquid is filled, a large number of beverage cans are accumulated at shops of ‘scrape’ per day by laborers. Moreover, there are a number of studies related to the utilization of these fibers under the capacity of reinforcing material in concrete that have been investigated and reported by the researchers and investigators [20]. In all studies, the researchers have worked on the use of soft drink can fibers or aluminium waste fibers to improve some of the parameters and characteristics of concrete [21], such as workability, fatigue strength, density, post crack behavior, energy absorbing capacity of concrete. Moreover, it is found that the inclusion of fibers in concrete has considerable effects to reduce the cracking, shrinkage, and permeability of concrete by using different types of fiber dosage and weightage ratios. However, use of soft drink can fibers in concrete for determining mechanical behaviour of concrete in terms of tensile and flexural strength is comparatively less investigated. Thus, this research work is aimed and limited to explore the effect of the addition of aluminium waste fibers or soft drink can fibers on these parameters and is undertaken in detail by using different weightage or dose of the fibers. Furthermore, compressive strength and other parameters are not taken as the targets to be investigated under this study, however, the problem of low tensile strength and flexural strength of concrete is addressed; that is the real gap and problem to be considered under this piece of research work.

2. Materials and Methods

2.1. Water and Cement

In this study, ordinary Portland cement (OPC was used, named Falcon cement line brand of BSS-12 / 1978, Pakistan standard. In this research, potable and drinking water of the city of Nawabshah, Pakistan was used for concreting. Characteristics of cement are mentioned in Table 1.

Table 1. Cement Properties

Properties	Value
Specific gravity	3.14
Fineness (m^2/kg)	225
Initial setting time	40
Final Setting time	138
Standard Consistency (%)	27

2.2. Aggregates

Hill sand of size less than 4.75 mm was used and nominal maximum size of 10 mm for coarse aggregates used in this study. Fine and coarse aggregates were obtained from Nooriabad, district Jamshoro. Aggregate properties are mentioned in Table 2.

Table 2. Aggregate Properties

Properties	Aggregates	
	Fine	Coarse
Specific gravity	2.61	2.66
Fineness Modulus	2.49	6.94
Water Absorption (% age)	1.69	1.38
Unit Weight (lb/ft^3)	102.5	97.5

2.3. Soft Drink Tin Fibers

Soft Drink Tin Fibers, the metallic waste, were collected from the different sources, such as, shops of scrape and marriage halls or clubs from Hyderabad, Nawabshah and Karachi. They were collected with the help of laborers. This soft drink can fiber is an aluminium metal container that is designed to take the liquid and beverages, such as soft drinks (carbonated), alcoholic liquids or beverages, energy and fruit juices or drinks etc. [22]. Beverages fibre cans are made up of aluminum nearly 75% or tin-plated steel about 25%. Worldwide production of beverages cans is nearly 470 billion cans per annum [23]. Chemical composition of modern beverage can be shown in the Table 3.

Table 3. Chemical Composition

Properties	Value				
	Fe	Si	Mg	Mn	Cu
Specific gravity	0.4	0.2	1.2	0.9	0.2
Fineness (m^2/kg)	0.2	0.1	4.7	0.3	< 0.1

2.4. Concrete Mix Design

Concrete mix design was selected for 30 MPa at 28 days as per British DoE method. Few trials were performed to check the mix design for the required strength; design mix proportion of concrete by DoE method was obtained as: 1:1.624:2.760 at 0.50 w/c ratio. The slump cone method was used for workability for freshly prepared concrete. In this research, 36 specimens were cast consisting of 6 batches and each batch was consisted of 6 specimens (3 cylinders and

3 prisms). Among 36 specimens of 6 batches, 6 specimens of 1 batch were made with control concrete (without inclusion of soft tin fibers) and remaining 30 specimens of 5 batches were made of fiber reinforced concrete (inclusion of fibers). Each 6 specimens were made using 1, 2, 3, 4, and 5% of soft tin can fibers respectively. After casting, the cylinders and prisms were demolded after 24 hours and then kept in water tank for 28 days for proper curing. After proper 28 days curing, they were tested for tensile and flexural strength.

2.5. Collection, Storage and Treatment of Soft Tin Fibers

Generally, the sources of getting beverage cans are the shops of scrape and marriage halls or clubs, where beverage cans are habitually used and were collected after drinking purposes. In this connection, estimated required quantities were collected from different shops of scrape from Nawabshah, Hyderabad and Karachi with the help of laborers from marriage halls and clubs. After collecting required quantity of beverage cans, they were stored in a storeroom in closed bags to protect from possible environmental effects.

Figure 1. Compressed and levelled top & bottom portions of cans

For good quality of work in this research work, cans were washed with detergent and cleaned with wire brushes. Top and the bottom portion were separated from the main body with the help of cutting iron cast cutters with sharp edges like scissors. Before making their fiber strips, top and bottom portion of cans were leveled by Forney hydraulic machine, Universal Testing Machine (UTM). In order to create roughness on surfaces for producing good bond, surfaces of fibers were scratched with steel wires.

Figure 2. Sketch work for cutting strips

After leveling, circular portions of top and bottom were sketched into small strips having a length of strip 25.4 mm (1 inch) width 5 mm and thickness 0.5 mm with the help of pencil and scale, and after completing the sketches fibers were cut according to given sketches with the scissors.

2.6. Concreting

2.6.1. Selection of Materials

As a matter of fact, good quality of concrete primarily be governed by the quality of materials selected and the materials used for concrete must follow the required specifications depends upon the required strength of concrete [24]. In this study, fresh cement (Falcon line brand cement) of approved quality, the crushed aggregate of good quality and potable water (drinking water) were used.

2.6.2. Proportioning of Materials for Concrete

Concrete must be adequate in two conditions namely that in which it is placed in position; and that in which it becomes ultimately hardened mass. Hence, both these conditions govern the choice of proportion [25]. The proportion of cement, fine aggregated and coarse aggregates according to DOE method, was obtained and suggested as 410: 666: 1134 (kg/m^3) or 1:1. 624:2.76

2.6.3. Batching of Concrete

Materials for making concrete can be batched either by volume or by weight. Weight batching was done in this study, every batch consisted of 6 specimens with 3 cylinders and 3 prisms (small beams), for each batch 8.15, 13.20, and 22.50 kg of cement, fine aggregated and coarse aggregates respectively were required as per mix design and 4.10 kg of water was used. In order to obtain uniformity, mixing was done thoroughly and mixing was done manually because work was limited and small only for 0.0198 m^3 quantity, ingredients were mixed on a watertight platform in the dry state.

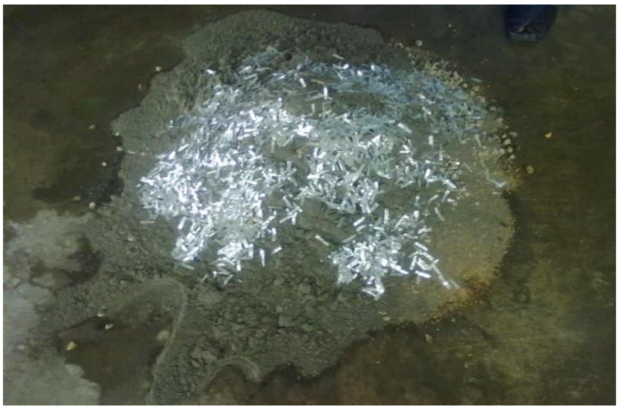

Figure 3. Mixing of soft drink can/aluminium can fibers in concrete

The quantity of fibers was mixed in a dry state with % of cement quantity used, as shown in Figure 3, then the estimated quantity of water was added and mixing was done uniformly till the concrete becomes uniform in color. It was preferred to add about 8 to 10% extra cement considering lesser efficiency of hand mixing [26].

2.6.4. Handling and Transportation of Concrete

As soon as the concrete was mixed, it was transferred for placing purpose besides the electrical table vibrator where the specimens were placed. In no case this time should exceed the initial setting time of cement further it should not cause segregation of it and should be economical and metal pans were used for this purpose.

2.6.5. Placing of Concrete

After transferring concrete from mixing place, placing of concrete was done carefully to the required place and in no case this time should exceed the initial setting time i.e., about 20 to 30 minutes, further once it was placed it should not be disturbed. Before placing of concrete into the specimens, specimens were oiled, cleaned, and wetted that they may be safely removed after casting and they may not absorb moisture from concrete, concrete was poured into the specimen in horizontal layers.

2.6.6. Compaction

In order to ensure a dense structure, free from air bubbles, compaction of concrete was done, it is one of the most important parts of concreting, compaction was done by table vibrator, concrete was poured into specimen on the base of electrical table vibrator and placing and compaction was carried out simultaneously and steel rod was used for uniform placing and remove air bubbles.

2.6.7. Curing of Concrete

The setting of concrete is due to the chemical action of concrete; this chemical reaction depends on the presence of water. Sufficient quantity of water should be there to continue the chemical action till the concrete becomes fully hardened. The cast specimens were put in a water tank for the period of 28 days; generally, beyond 28-day strength is comparatively slower [27]. Before curing, water tank was cleaned and foreign matter (organic and inorganic) was removed. Moreover, drinking water was used for curing.

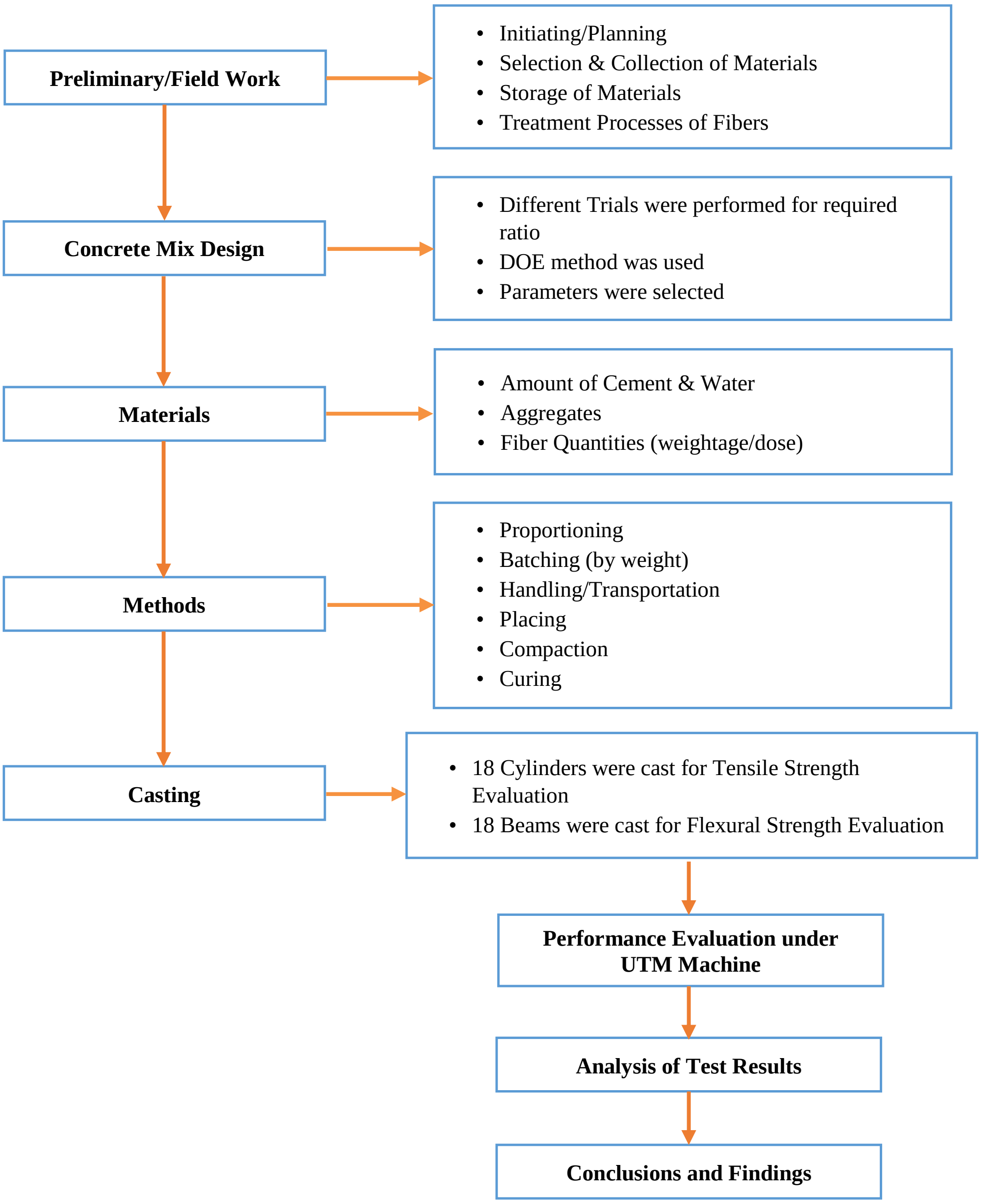

Figure 4. Flowchart showing research methodology

3. Study Parameters and Laboratory Tests

For study purpose, there were two parameters under consideration i.e., indirect tensile strength and flexural strength and individually every parameter is described in detail.

3.1. Indirect Tensile Strength

To investigate the indirect tensile strength (splitting), cylindrical molds with 100 mm in diameter and 200 mm in length were cast. Total 18 cylindrical specimens were cast. The cylinders were designated and divided into six series labelled as A, B, C, D, E, and F.

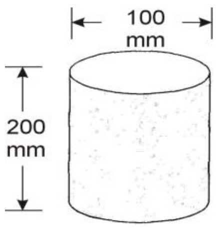

Figure 5. Section details of cylinderical mould

Figure 6. Experimental setup under UTM

Series A contained three cylinders labelled as A1, A2 and A3. These three cylinders were set as control specimen and were without inclusion of fibers. Series B contained three cylinders labelled as B1, B2 and B3. These three specimens were added with 1% of soft drink/aluminium can fiber in cement concrete. In similar fashion, series C, D, E and F contained C1, C2, C3, D1, D2, D3, E1, E2, E3 and F1, F2, F3 cylinders were added with 2, 3 ,4 and 5% of soft drink tin fiber respectively. For easy removal of cast material from the molds, the crude lubricant was applied properly on inner surfaces. Concrete was placed and poured properly throughout its length then compacted well. To conduct the experimental test, the cylinder specimens were placed under Universal Testing Machine (UTM) as shown Figure 6.

Figure 7. Splitting failure at ultimate load

Figure 8. Splitting at ultimate load

The indirect or splitting tensile strength of concrete was calculated by using expression, $F_t = 2P/\pi LD$ to conform with ASTM C 496-96 [28], where P= maximum possible load at failure stage, L= length of cylinder in mm, π = constant (3.142).

3.2. Flexural Strength

The beam specimens of 500×100×100 mm size were cast and tested with and without inclusion of fibers for normal conditions. Total 18 number of beams specimen were cast. Likewise, the specimens were designated and divided into six series labelled as A, B, C, D, E, and F. Series A contained three beams labelled as A1, A2, and A3. These three specimens were treated as control specimen and were without inclusion of fibers. Likewise, series B contained three beams designated as B1, B2, and B3. These three specimens were added with 1% of soft drink/aluminium can fiber in cement concrete. In similar fashion, series C, D, E and F contained C1, C2, C3, D1, D2, D3, E1, E2, E3, and F1, F2, F3 beams were added with 2, 3, 4, and 5% of soft drink tin fibers respectively. To investigate the experimental test, the prisms were placed on the loading frame. Two-point loading system was used for conducting the test as shown in Figure 10.

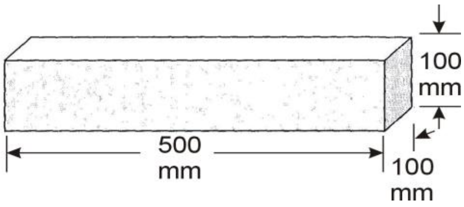

Figure 9. Section details of prism mould

Figure 10. Experimental setup under Two-point loading system

Figure 11. Failure at ultimate flexural load

Figure 12. Cracks at failure stage

The flexural strength, popularly called average modulus of rupture, was calculated using formula $F = PL/BD^2$ to conform with ASTM C78 [29], F = Average modulus of rupture, P = ultimate flexural load in N, L = length of specimen in mm, B = width of beam in mm, D = depth of beam in mm.

3.3. Plan for Study and Schedule of Work

Total 36 specimens were cast, consisting of 6 batches and every batch was consisting of 6 specimens (three cylinders and three prisms), total plan and schedule work for study is tabulated in Table 4.

Table 4. Plan and Schedule work

Batch No.	Specimen Type	Volume of Specimen	Number of Specimen per batch	Total Volume per batch	Material per batch (kg)					Date of Casting
					Cement	F.A	C.A	Fiber (% of Cement)		
								%age of Cement	Quantity of Fiber (g)	
1	Cylinder	0.0016	3	0.0048	8.15	13.2	22.5	0% (Normal)	---	06-Aug-2012
	Prism	0.005	3	0.015						
2	Cylinder	0.0016	3	0.0048	8.15	13.2	22.5	1%	81.5	08-Aug-2012
	Prism	0.005	3	0.015						
3	Cylinder	0.0016	3	0.0048	8.15	13.2	22.5	2%	163.0	20-Aug-2012
	Prism	0.005	3	0.015						
4	Cylinder	0.0016	3	0.0048	8.15	13.2	22.5	3%	244	28-Aug-2012
	Prism	0.005	3	0.015						
5	Cylinder	0.0016	3	0.0048	8.15	13.2	22.5	4%	326.0	29-Aug-2012
	Prism	0.005	3	0.015						
6	Cylinder	0.0016	3	0.0048	8.15	13.2	22.5	5%	407.5	05-Sep-2012
	Prism	0.005	3	0.015						

4. Experimental Results and Discussions

4.1. Test Results and Discussions of the Effect of Soft Drink Tin Fibers on Indirect Tensile Strength of Concrete

Total 18 specimens (cylinders) were experimentally tested for determining indirect or splitting tensile strength in conformation with ASTM C 496-96. The tensile strength was calculated by using expression $F_t = 2P/\pi LD$. The results obtained from the tensile test at 28 days are tabulated in Table 5.

Table 5. Results of Indirect Tensile Strength of Concrete at 28 days

Sr. No.	% of Fiber	Ultimate Load (N)	Average Load (N)	Average Split Tensile Strength (MPa)	Increase in split tensile strength (%)
1	A-0% (Normal)	124200 109300 95698	109733	3.49	---
2	B-1%	137251 115395 101630	118092	3.75	7.45
3	C-2%	125913 123015 115076	121335	3.86	10.60
4	D-3%	121037 118791 135414	125081	3.98	14.04
5	E-4%	140501 114039 125051	126532	4.03	15.39
6	F-5%	120522 123900 124812	123078	3.92	12.24

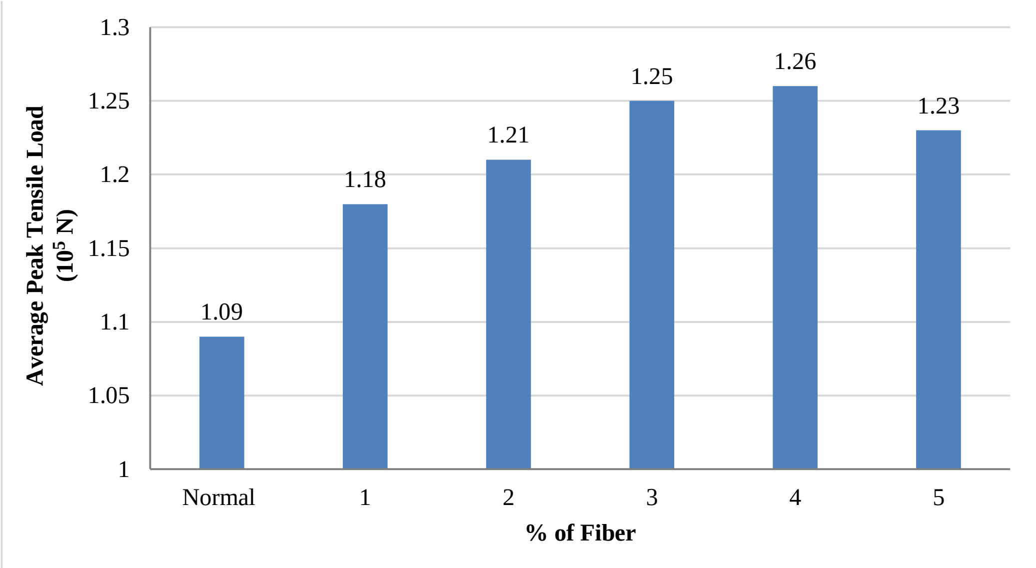

Figure 13. Comparison of average peak tensile load of normal concrete with average peak tensile load of fiber reinforced concrete

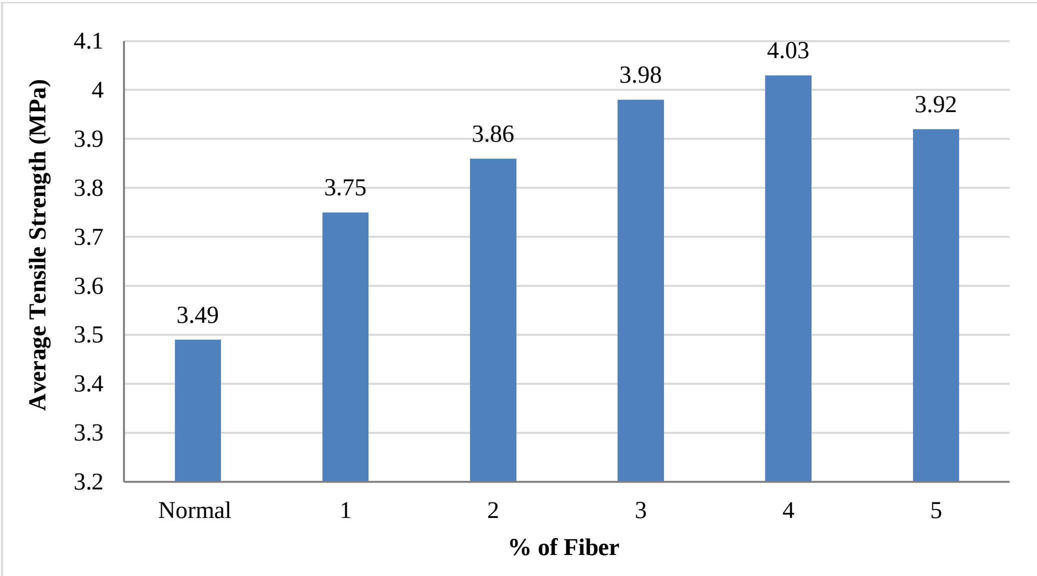

Figure 14. Comparison of average tensile strength of normal concrete with average tensile strength of fiber reinforced concrete

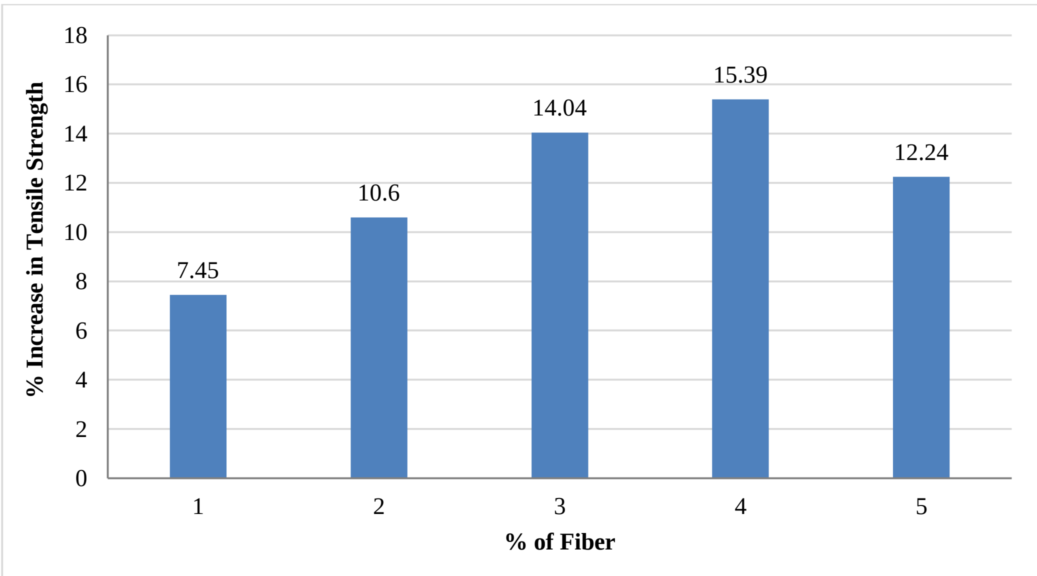

Figure 15. Comparison of percentage increase of tensile strength with percentage increase of fiber

The results reveal that the indirect tensile strength increases as compared to normal specimen. It was observed that tensile strength is increased with the addition 4% of fibers level. However, value reduces beyond 4% addition of fibers. The results show that the addition of fibers in concrete improves the tensile strength up to 15.40% as compared to plain concrete.

4.2. Test Results and Discussions of the Effect of Soft Drink Tin Fibers on Flexural Strength of Concrete

Likewise, total 18 beams were also experimentally tested for determining flexural strength under two-point loading system. Three specimens named as A1, A2, A3, were called as control specimens, other specimens were added with fiber quantity of 1, 2, 3, 4 and 5%. The test results are tabulated in Table 6.

Table 6. Results of Flexural Strength of Concrete at 28 days

Sr. No.	% of Fiber	Peak Load (kN)	Flexural Strength (MPa)	Average Peak Load (kN)	Increase in flexural strength (%)
1	A-0% (Normal)	8.09	4.09	8.12	---
		8.01	4.06		
		8.25	4.15		
2	B-1%	8.68	4.39	8.76	8.04
		8.75	4.42		
		8.86	4.49		
3	C-2%	9.15	4.57	9.24	11.46
		9.37	4.73		
		9.20	4.41		
4	D-3%	9.35	4.61	9.70	18.05
		9.75	4.88		
		9.98	5.05		
5	E-4%	9.91	4.98	9.96	18.50
		12.03	4.09		
		17.95	5.53		
6	F-5%	9.65	4.60	9.42	15.30
		9.15	4.06		
		9.46	4.50		

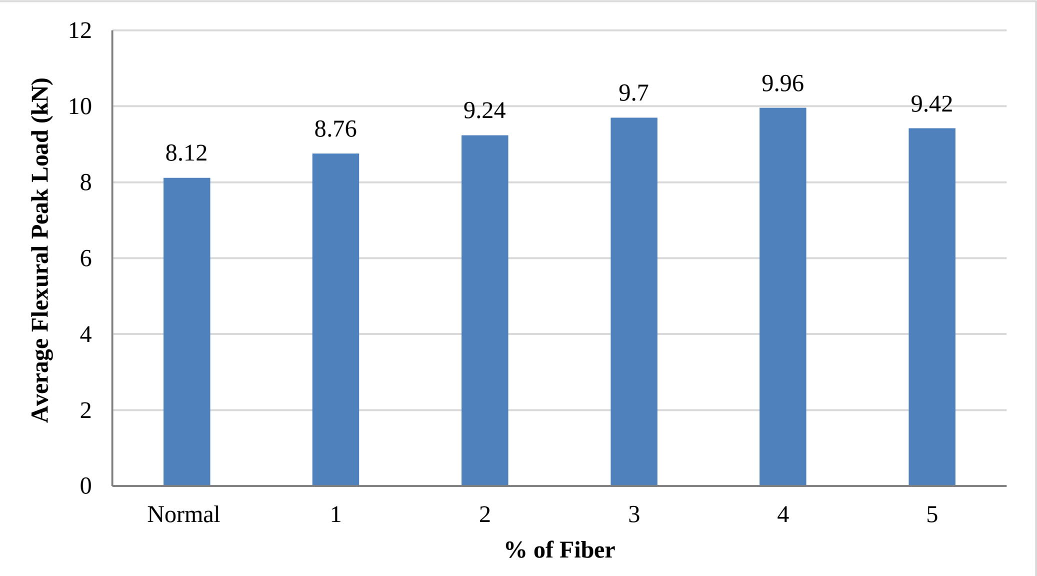

Figure 16. Comparison of average flexural peak load of normal concrete with average flexural peak load of fiber reinforced concrete

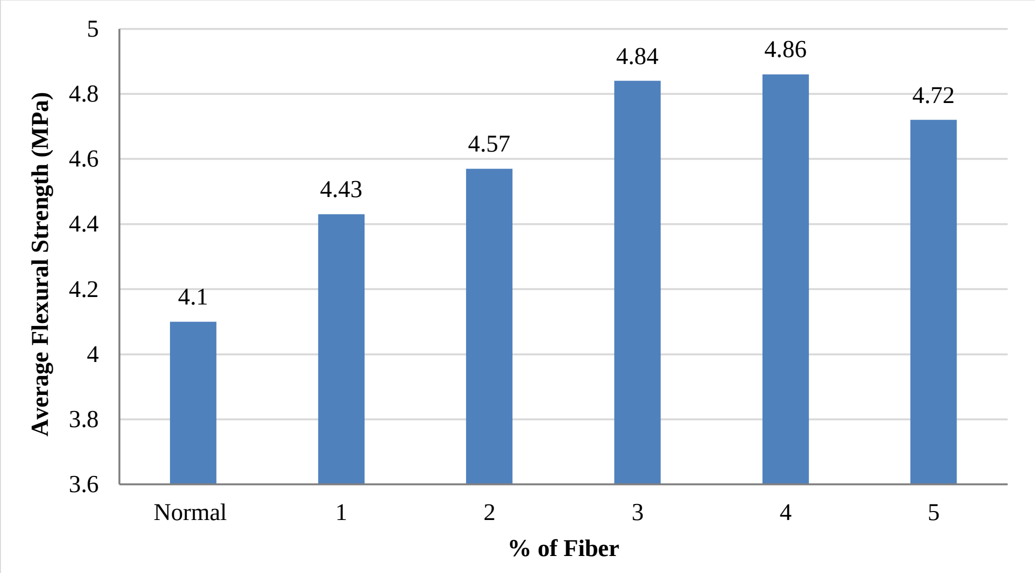

Figure 17. Comparison of average flexural strength of normal concrete with average flexural strength of fiber reinforced concrete

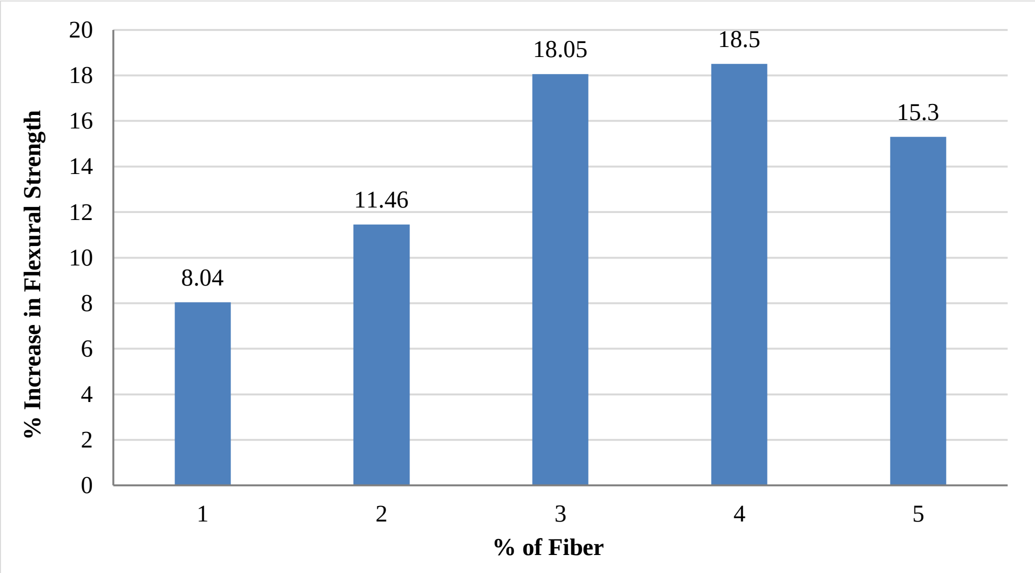

Figure 18. Comparison of percentage increase of flexural strength with percentage increase of fiber

The results show a significant increase in flexural strength as compared to control specimens. It was observed as the load was increased then cracks started to appear over the shear span from the either side of beam. Specimens with inclusion of fibers added give more flexural strength as compared to the plain specimen. The results obtained from the tests show a substantial increase of flexural strength of beams up to 4% addition of fiber level, moreover, 5% inclusion of fibers causes a reduction in strength. The results show that optimum result is obtained with the 4% fiber addition and flexural strength increases by 18.50% as compared to control specimens.

5. Conclusions and Recommendations

In this study, soft drink/aluminium can fibers are used in concrete as fibers to make fiber reinforcement concrete. Soft drink tins are the substitute for fibers and added to improve mechanical properties of concrete. Soft drink can fibers with the size of 25 mm x 5mm x 0.5mm are used in various proportions and percentages such as, 1, 2, 3 ,4 and 5% based on the weight of cement used. Based on the experimental results obtained, the following conclusions and suggestions can be drawn from the study of the effect of soft drink tin fibers on the concrete properties.

- The addition of soft drink tin fibers has improved the tensile and flexural strength of concrete;
- With the inclusion of soft drink tin fibers in concrete, the concrete remained workable and workability was not affected;
- The results of the indirect tensile strength test on cylinders reveal that the ultimate load-carrying capacity of the cylinder increases by 15.40 % with the addition of 4% soft drink tin fibers;

- The results of the flexural strength test on beams show that the ultimate load-carrying capacity of the beam increases by 18.50 % with the addition of 4% soft drink tin fibers;
- The use of soft drink tin fiber as a reinforcing material in concrete imparts strength up to 4% soft drink tin fiber level. A higher ratio of soft drink tin fiber leads to segregation consequently affects the strength;
- Fiber reinforced concrete mixes can yield better tensile and flexural strengths than that of control concrete mix at 28 days;
- Further extensive study can be carried out in control conditions;
- Better results can be expected by using different sizes and %age of soft drink tin fibers;
- Waste materials (soft drink tin fibers) can be utilized in a better way by giving special treatment and as a result, environmental pollution can be controlled.

6. Declarations

6.1. Author Contributions

Conceptualization, I.A.C. and A.S.; methodology, I.A.C.; formal analysis, I.A.C.; data curation, I.A.C.; writing—original draft preparation, I.A.C.; writing—review and editing, I.A.C. and A.S.; supervision, A.S. All authors have read and agreed to the published version of the manuscript.

6.2. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

6.3. Funding

This work was funded by Quaid-e-Awam University of Engineering, Science &Technology, Nawabshah, Pakistan. The financial support is gratefully acknowledged.

6.4. Conflicts of Interest

The authors declare no conflict of interest.

7. References

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