An Investigation on Using Pop-cans Wastes Fibers on the Mechanical Properties of Concrete

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***Abstract*—This paper presents an experimental investigation carried out to study the effect of using tin fibers (obtained from the pop-cans wastes) on enhancing the mechanical properties of plain concrete. It is well known that concrete is mainly used to resist compressive loads and it has very low tensile resistance but adding such fiber to the concrete mixtures can relatively increase its tensile strength. These fibers can bridge the cracks resulted from tensile loads applied to concrete and prevent it from widening.**

By using the wastes of pop-cans can have double benefit; as from the environmental side it reduces the amount of unused wastes and on the economic side improves the properties of concrete without any extra cost for the concrete production. The experimental program was designed to investigate the effect of adding the tin fibers on three main properties of concrete; compressive strength, indirect tensile strength and flexural strength. The fibers were used at ratios of 0.5%, 1%, 2% and 3% by weight of cement. The results showed that the compressive strength is negatively affected by the addition of the fibers to the mix, while both tensile strength and flexural strength improves by adding the fibers. And for the ratios used within this study, the more the fibers were added the more the tensile and flexural resistance of concrete was increased.

***Index Terms*—Pop-cans wastes, mechanical properties of concrete.**

I. INTRODUCTION

The use of industrial and agricultural wastes in concrete has attracted the attention of many researchers worldwide due to its significant economic and environmental effect. The industrial wastes in particular were considered a problem and people used to burn these wastes to get rid of it. Later on, these wastes were found to be of great use in many applications such as increasing the strength of concrete structures and finding cost effective material.

An example for the industrial wastes is pop-cans which had been a point of research for many scientists who tried to investigate its effect on the concrete properties. The pop-cans have been used as fiber additives to concrete and had proved to improve the mechanical properties of concrete. The fibers can be used by itself only or by adding other supplementary cementing materials which also showed a good combination to improve the mechanical properties of concrete [1].

While all the researchers proved that using the pop-cans fibers in concrete increases its tensile and flexural resistances significantly [2-10], the effect of pop-cans fibers on the compressive strength of concrete had been a point of debate for researchers where some researchers found out that it increases the compressive strength [2-8] while others showed that it decreases the compressive strength of concrete [9,10].

II. EXPERIMENTAL PROGRAM

The experimental program included testing a total number of 60. Where three different types of tests were carried out on the concrete specimens namely; compression tests, split tension tests and flexure tests. The shape of specimens was specified accordingly. Cubic specimens of 15*15*15 cm dimension were used to measure the compressive strength of concrete; cylindrical specimens of 15*30 cm dimension were used to measure the indirect tensile strength of concrete. And for the flexure test, prisms(beams) with dimensions of 50*10*10 cm were used. Figures 1 and 2 show the split tension and flexure tests. Concrete mixes with different fiber contents were casted to evaluate the effect of using tin fiber obtained from pop- cans wastes on the different mechanical properties of concrete.

Concrete mix was designed using British method DOE, the designed compressive strength of the concrete mix was aimed to be 30 MPa after 28 days. The tin fibers were added to the concrete mixtures as a percentage of the cement weight. A control mix was used without any fibers and four different ratios of fibers were used in this research. The fibers were used at ratios of 0.5, 1, 2 and 3% of cement weight.

Figure 1. Split tension test

Figure 2 Flexure test

Materials:

Various materials were used within the experimental program, the materials were first tested to ensure that it satisfies the Egyptian specifications and meets the codes limits.

Cement

Ordinary Portland cement (OPC) produced by Suez Company was used in all mixes. The grade used was CEM I 42.5 N. Testing of cement was carried out according to the Egyptian Standard Specification (ES: 2421/2009).

Aggregates

The coarse aggregate used in this work consisted of Crushed dolomite with specific gravity of 2.57 (as measured). To avoid the effect of fine materials in the coarse aggregate, coarse aggregates was washed and left to dry for 24 hours before being used. local natural coarse aggregate from Ataka Mountain in Suez city was used in the experimental work. The coarse aggregates had nominal maximum size of 12.5 mm. The sand used in this investigation was natural siliceous sand, with fineness modulus 2.48.

Tin fibers

The tin fibers used in the experimental program were obtained from pop-can wastes, where it was first shredded into strips having a length of 40 mm and width of 4mms to obtain an aspect ratio of 10. The shredded fibers were cleaned with water and left to dry for 24 hours be it was placed in the concrete mixture. Figure 3 shows tin fibers used while figure 4 shows the fibers in the concrete mix.

Water used in this study for mixing the concrete and curing the specimens for 28 days was the regular municipal water.

Figure 3. Tin fibers

Figure 4. Tin fibers in concrete

III. RESULTS AND DISCUSSION

Compressive strength

For the 28-day age, all the mixes containing tin fibers showed a significant reduction of compressive strength after 28 days, the reduction varied from 15% reduction at the ratio 1% of fibers to 30% reduction in compressive strength corresponding to 2% and 3% fibers ratios. This reduction can be attributed to the smoothness of the fibers used which might need to be roughened to increase the bond strength with cement; this can create planes of failure within the concrete paste. Kampa[10] proposed twisting the strips to improve its bond to the concrete, this methodology was not adopted in this research as the tin cans strips were thin that it will be deformed within the concrete paste during mixing process. Table 1 shows the compressive strength of specimens of different mixing proportions. While figure 3 shows the effect of adding fibers with different ratios on the compressive strength of concrete.

Table 1. 28-day compressive strength

Configuration	Specimen #	28 – day Compressive Strength (MPa)	Average (MPa)
Control	1	33.70	34.30
	2	33.90	
	3	35.30	
F – 0.5%	1	28.97	29.09
	2	29.64	
	3	28.66	
F – 1%	1	21.37	26.72
	2	29.33	
	3	29.46	
F – 2%	1	26.42	24.02
	2	22.97	
	3	22.68	
F – 3%	1	26.53	23.91
	2	21.28	
	3	23.91	

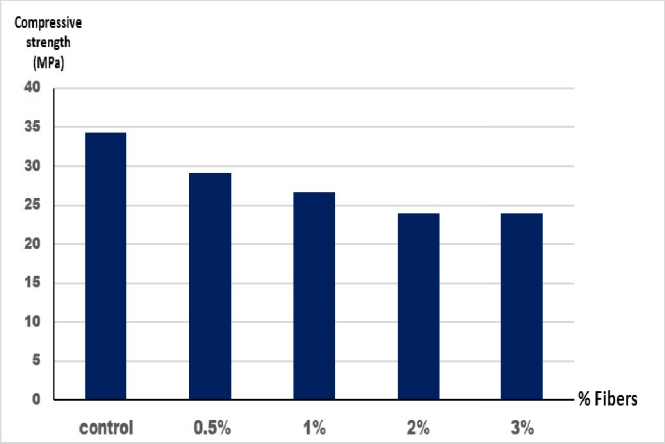

Figure 3. 28-day compressive strength

Tensile strength

In order to measure the effect of fibers on the tensile strength of concrete, a split tension test was performed on standard cylindrical specimens. Adding the tin fiber to the concrete mixes improved the tensile strength concrete specimens where at 0.5% fiber the tensile strength increased by 3% and for1% fibers ratio the tensile strength increase by 4%, these two ratios shows slight increase in tensile strength. On the other hand, there was a significant increase in tensile strength for 2% and 3% fibers where the increases in tensile strength was 13% and 18% respectively. Figure 3 shows the increase in tensile strength with increasing the percentage of tin fibers added to the concrete mixture. Table 2 shows the indirect tensile strength of specimens of different mixing proportions. While figure 4 shows the effect of adding fibers with different ratios on the indirect tensile strength of concrete.

Table 2. Tensile strength of specimens

Configuration	Specimen #	Tensile strength (MPa)	Average (MPa)
Control	1	3.17	3.12
	2	3.00	
	3	3.20	
F – 0.5%	1	3.14	3.22
	2	3.34	
	3	3.18	
F – 1%	1	3.26	3.25
	2	3.19	
	3	3.31	
F – 2%	1	3.62	3.55
	2	3.51	
	3	3.52	
F – 3%	1	3.68	3.69
	2	3.63	
	3	3.75	

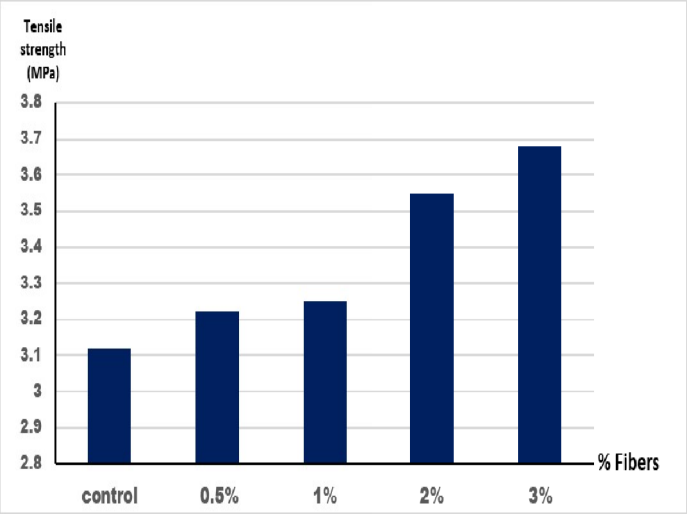

Figure 4. Tensile strength

Flexural Strength

The results of the mixes with different fibers ratios showed an increase in the flexural strength of the specimens when compared to control ones. Using 0.5% tin fibers in concrete resulted in 3% increase in the flexural strength, while using 1% tin fibers showed almost 5% increase in strength. The most increase in flexure strength was obtained when the tin fibers was added with 3% and that was corresponding to

13.7% increase in flexural strength. Figure 4shows the effect of increasing the percentage of tin fibers on the flexural resistance of concrete prisms. Table 3 shows the flexural strength of specimens of different mixing proportions. While figure 5 shows the effect of adding fibers with different ratios on the flexural strength of concrete specimens.

Table 3. Flexural strength of specimens

Configuration	Specimen #	Flexural strength (MPa)	Average (MPa)
Control	1	8.24	8.32
	2	8.00	
	3	8.74	
F – 0.5%	1	8.32	8.57
	2	8.83	
	3	8.57	
F – 1%	1	8.61	8.72
	2	8.52	
	3	9.03	
F – 2%	1	8.73	9.12
	2	8.91	
	3	9.72	
F – 3%	1	8.93	9.46
	2	10.02	
	3	9.43	

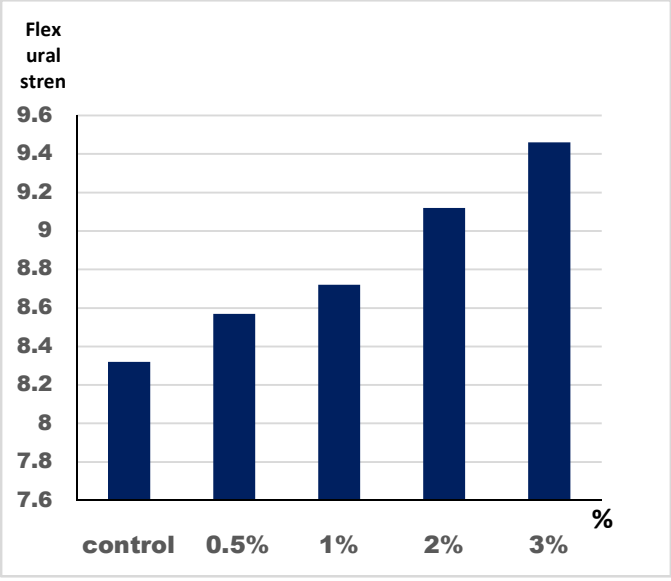

Figure 5. Flexural strength

IV. Conclusions

The tin fibers obtained from shredding the pop-cans wastes into strips of aspect ratio 10 were used as additive to concrete with different percentages varying from 0.5% to 3 %. The results showed that adding these fibers dropped the compressive resistance of the concrete slightly and by increasing the percentage of fibers in concrete the reduction in strength increases. While adding the fibers with the same percentages improved both the indirect tensile strength and the flexural strength of concrete significantly and the 3% fibers showed the highest results in increasing both flexural and indirect tensile strength.

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