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Effect of Metal Tanks Wastes as Fibers on Some Concrete Properties

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Abstract. Recycling of waste materials limit solid wastes and saves natural resources. The investigations of using waste materials in concrete mixtures increase day by day. Use of waste materials in concrete gave economical disposal of wastes. This paper investigates the possibility of using metal wastes strips resulting from civilian factories of domestic storage tanks as fibers and its effect on some concrete properties which include workability of fresh concrete, compressive strength, splitting tensile strength and flexural strength. Five concrete mixtures with different ratios of metal wastes fibers, (0, 0.5, 1, 1.5 and 2) % of concrete volume have been added to produce the concrete composites. Three Cubes, cylinders and prismatic samples have been made for compressive, tensile and flexural strength tests respectively for each mixture. The mechanical properties of mixtures were analyzed in comparison to the control mixture. The results showed that the metal waste fibers could be used successfully to enhance the mechanical properties of concrete. An increase in metal wastes fibers content led to increase in strength properties of concrete, and the optimum percentage of metal wastes fibers for strength improvement are ranged between 1.0-2.0%.

1. Introduction

Concrete material is one of the most commonly used in construction of the buildings. It has a weakness point representing by weak tensile strength, and the brittle behaviour which cause sudden failure without any precautions observed in the structure [1]. This behaviour can be enhanced by adding of fibers, mainly steel fibers which are in common discontinuous, short and arbitrarily spread throughout the concrete mixture to produce a composite construction material called as fiber reinforced concrete. Fibers can reduce cracking more successfully because of their trend to be more closely spaced compared with conventional reinforcing steel bars [2]. Recycling of waste materials reduce solid wastes and contribute as an alternative solution for the waste disposal. Using of waste materials in concrete mixture has rapidly increased in recent years. Many researchers have been studied the use of such wastes, and its effect on mechanical properties of concrete. Ghailan [3] stated that the rebound number, modulus of rigidity and chemical resistance of plain concrete could be enhanced when industrial solid waste formed from steel industry used as a replacement for coarse aggregate. Ismail and Al Hashmi [4] insured that plastic wastes could be used as partial replacement for sand to decrease the cost of concrete materials and to propose plastic wastes disposal. Kandasamy and Murugesan [5] studied the effect of polyethene fibers on the strength properties of concrete, they found that compressive and tensile strengths had been increased by (5.12, 1.63) % respectively when using polyethene fibers with a proportion of 0.5% by weight of cement in concrete. Ismail and Al Hashmi [6] studied the effect of partial replacement of sand with plastic wastes and iron filings materials, and its effect on concrete properties. They observed that a good result on strength properties can be achieved when the replacement mentioned is occur. Al zaid [7] studied the effect of partial replacement of fine aggregate with iron fillings wastes. He found that the optimum percentage of iron



fillings is approximately 10% which gives a better result in compressive and tensile strength of concrete. Qureshi and Ahmed [8] have studied the possibility of replacement of steel reinforcement bars with different sizes of metal wastes chips. They found that metal wastes showed a reasonable performance in strength properties of concrete can achieved when a partial replacement is obtained.

The objective of this research paper is to investigate the beneficial effects of adding metal wastes which produced during the manufacture of storage tanks as fibers, and its effect on the mechanical properties of concrete.

2. Materials and mix design

2.1. Materials

In this research ordinary portland cement have been used. The chemical and physical properties of cement have been found in accordance with ASTM C114 [9], ASTM C109 [10], ASTM C204 [11] and ASTM C191 [12] respectively. These properties are presented in Table 1.

Table 1. Chemical analysis and Physical properties of cement.

<i>Oxide Composition</i>	SiO ₂	Fe ₂ O ₃	Al ₂ O ₃	CaO	MgO	SO ₃
Content (%)	21.60	2.69	6.4	63.11	2.84	2.29
Limits	21-24	2-4	4-7	63-67	<5	2-3.5
<i>Oxide Composition</i>	Loss of ignition		Lime saturation factor		Insoluble residue	
Content (%)	0.88		0.92		0.33	
Limits	≤ 3%		0.66-1.02		≤ 0.75%	
<i>Mineralogical components</i>	C3S		C2S	C3A	C4AF	
Content (%)	45.92		28.88	11.16	7.98	
Limits	45-60		15-30	6-12	6-8	
<i>Physical properties</i>						
Compressive strength (MPa)	ASTM C109					Limits
Age (3days)						≥12
Age (7days)						≥19
Fineness (m ² /kg)						≥280
ASTM C204						
Setting time (hrs.)	Initial		Limit		Final	Limit
ASTM C191	1.75		≥45min.		3.50	≤10 hrs

River sand was used with fineness modulus of 2.63, specific gravity 2.54 and Absorption 1.8%. Particle size distribution of the sand was analyzed according to ASTM C136 [13].

River rounded gravel comply with the ASTM C33 [14] was used with a maximum aggregate size of 10 mm, specific gravity 2.5 and Absorption 1.26%. Table 2 shows Gradation of aggregate used in the study.

Table 2. Particle size distribution of aggregate

Sieve Size (mm)	Lower limit	%Passing of sand	Upper limit	Sieve Size (mm)	Lower limit	%Passing of gravel	Upper limit
4.75	95	100	100	20	100	100	---
2.36	80	86	100	12.5	90	95	100
1.18	50	74	85	9.5	40	65	70
600μm	25	54	60	4.75	0	5	15
300μm	5	23	30	2.36	0	0	5
150μm	0	0	10				

Metal Wastes Fibers (MWF) were obtained from the civilian factories that manufactured water storage tanks, the scrapped industrial wastes at the site of those factories were collected and cut into random

average pieces 15-50 mm in length, and 0.5-3 mm in width to represent the fiber. These dimensions are simulate the manufactured steel fibers. The MWF used in this study are presented in Figure 1 a and b.

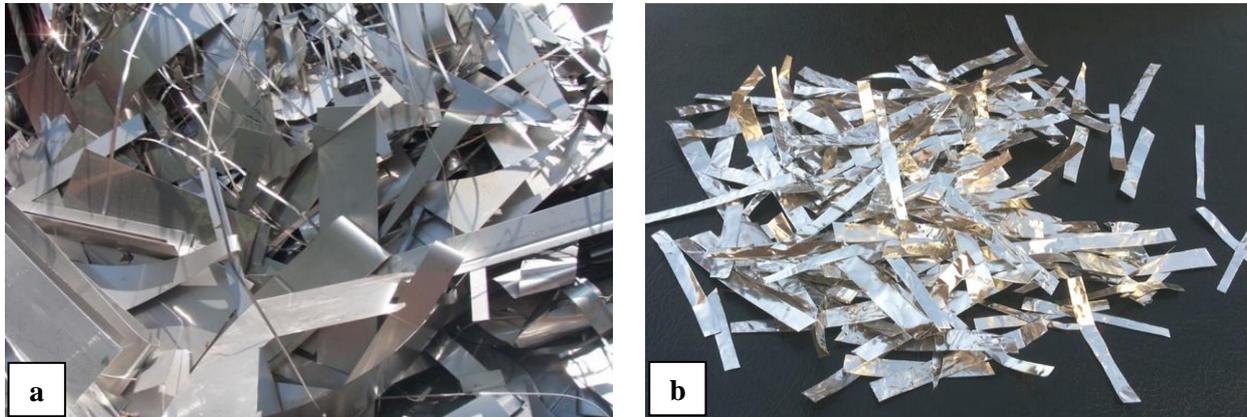


Figure 1. a) Scrapped industrial waste at the site of factories, b) Metal wastes fibers.

2.2. Concrete mixes composition

Five concrete mixtures were prepared including plain concrete (M0), and four mixtures prepared with different proportions of MWF of 0.5, 1, 1.5 and 2% by volume of concrete, all the prepared concrete mixtures have the same water/cement ratio of 0.5. The mix proportions details are shown in Table 3.

Table 3. Composition of concrete mixtures

Mix	Cement content	Mix proportion (kg/m ³)			Metal fibers	Water content
		Aggregate content				
		sand	gravel			
M0	355	603.5	1242.5	0	177.5	
M1	355	603.5	1242.5	39	177.5	
M2	355	603.5	1242.5	78	177.5	
M3	355	603.5	1242.5	117	177.5	
M4	355	603.5	1242.5	156	177.5	

2.3. Specimen preparation and testing program

For concrete mixture preparation, coarse aggregate, fine aggregate and dry cement were mixed for several minutes in concrete mixer with gradually addition of water. MWF added gradually to the mixture from 2 to 5 mins to prevent the flocculation of the metal wastes fibers and to get a homogeneous mixture as shown in Figure 2. Slump test had been done in accordance with ASTM C143 [15] to determine the concrete mixtures workability. For each concrete mixture, a total of nine specimens were cast, including three cubical samples of (100×100×100) mm for the compressive strength test, three cylindrical samples of (100×200) mm for the splitting tensile strength test, and three prismatic samples (100×100×500) mm for the flexural strength test, mixtures were cast in steel moulds. A vibration table was used to consolidate the concrete. After 24 hours from casting, the samples are retrieved from the moulds and submerged in water tanks for 28 days curing duration, then the samples were retrieved from the tanks and allowed for surface drying to few minutes before testing. Compressive strength was tested at 28 days according to (BS 1881: Part 116) [16]. Splitting tensile test and flexural strength were tested at 28 days according to ASTM C496 [17] and ASTM C78 [18] respectively.



Figure 2. Metal wastes fibers concrete mixture

3. Results and discussions

3.1. Effect of MWF on workability

Figure 3, a and b shows the slump test behaviour for the plain concrete and MWF concrete mixture respectively. Fig. 4 shows the variation of slump test values of the MWF concrete mixture. It is obvious from the figures that the slump value decrease with the increasing of MWF content. The reductions of the slump compared with control mix are 7.8%, 19.4%, 41.7% and 70.9% for M1, M2, M3 and M4 respectively. This reduction can be explained to the addition of fibers which obstruct the movement of coarse aggregate and decrease the mobility of materials. This result agrees with the researchers i.e. Figueiredo et al. [19].

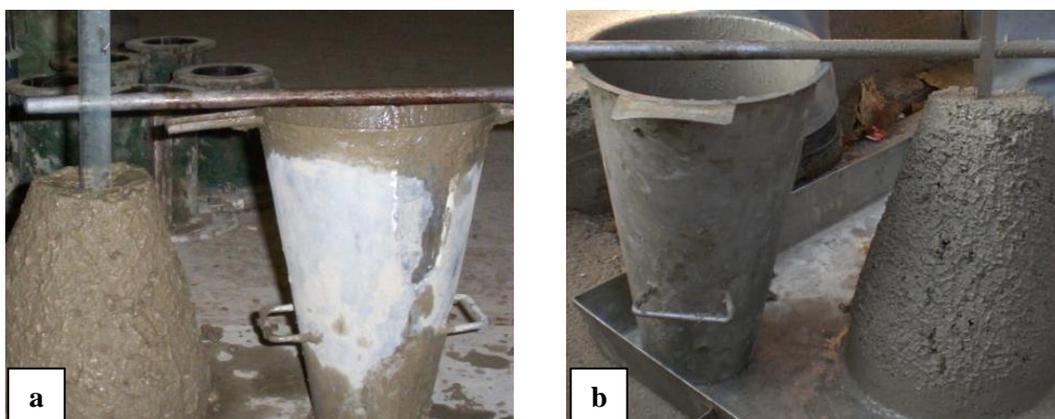


Figure 3. Effect of metal wastes fibers on slump, a- plain concrete, b- metal wastes fibers concrete

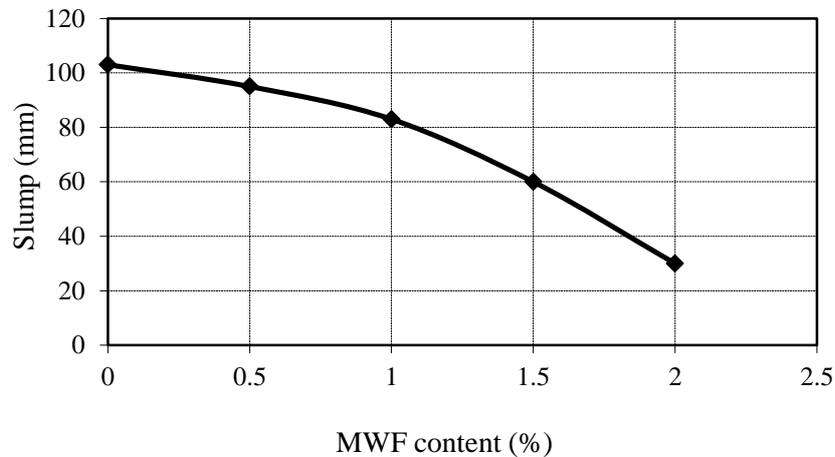


Figure 4. Effect of metal wastes fibers content on slump behaviour

3.2. Effect of MWF on compressive strength

The variation of the compressive strength of concrete mixtures at age of 28 days of the MWF concrete mixture is presented in Figure 5. It is obvious that the optimum percentage of MWF is 1% that gives the maximum compressive strength value. It was recorded as 36.8 MPa, which is 1.10 times compared with the compressive strength of the control mix. Thereafter, the compressive strength dropped slightly, this dropped might be due to the insufficient dispersing of the fibers in the concrete during mixing. This behaviour agrees with the researchers *i.e.* Song and Hwang [20]. The percentage increment ratio of compressive strength compared with the control mix are 4.8%, 9.9%, 5.4% and 2.7% for M1, M2, M3 and M4 respectively. This increasing can be explained to the significant contribution of metal wastes fibers that successfully holds the micro-cracks in the mass of concrete. This result agrees with numerous researchers *i.e.* Mahadik *et al.*, [21].

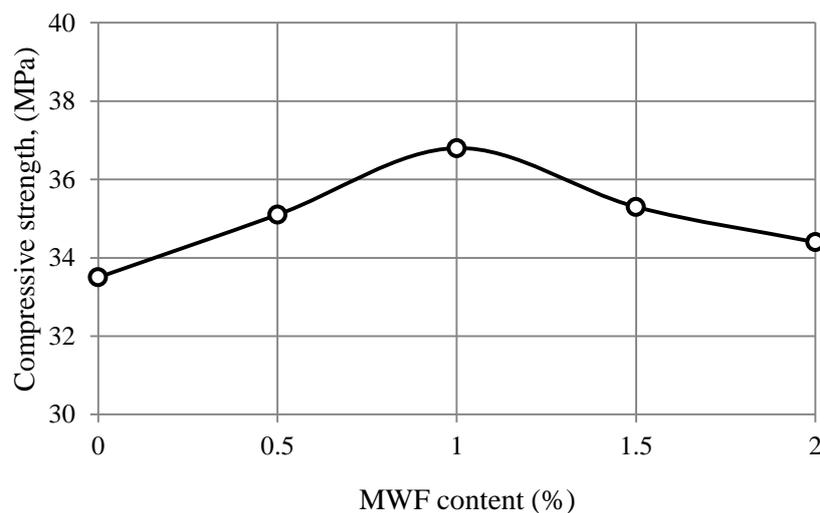


Figure 5. Effect of metal wastes fibers content on compressive strength

3.3. Effect of MWF on splitting tensile strength

The variation of splitting tensile strength of concrete mixtures at age of 28 days of MWF concrete mixture is presented in Figure 6. It can be seen that splitting tensile strength is increasing with the increase of MWF content up to 1.5% MWF content, after this proportion the increment is going to be decreased. Therefore, it can say that the optimum percentage of MWF content is 1.5-2.0%. The

percentage increment ratio of splitting tensile strength compared with the control mix are 9.8%, 20.5%, 28.3% and 31.6% for M1, M2, M3 and M4 respectively. This improvement can be explained to the existing of metal wastes fibers in concrete which control on the cracking proceeding. This result agrees with numerous researchers, i.e. Ramadoss [22].

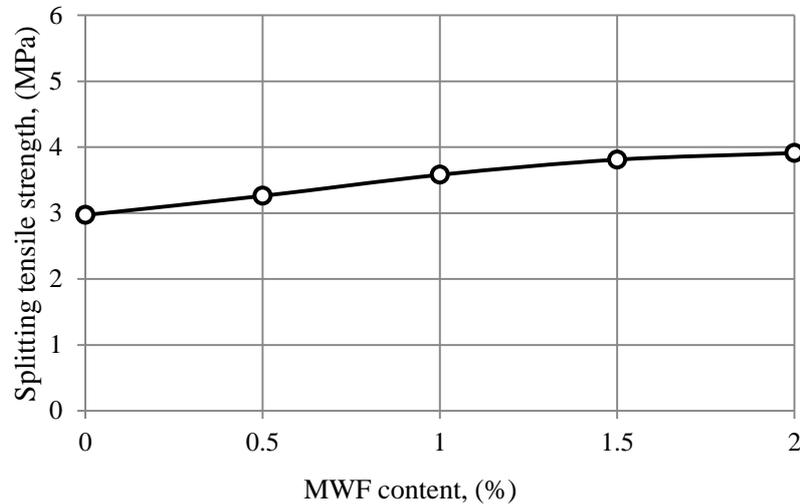


Figure 6. Effect of metal wastes fibers content on splitting tensile strength

3.4. Effect of MWF content on flexural strength

The variation of the flexural strength of concrete mixtures at age of 28 days of MWF concrete mixture is presented in Figure 7. It seems that the effect of MWF on flexural strength is similar to its effect on splitting tensile strength. The percentage increment ratio of flexural strength compared with the control mix are 12.7%, 23.6%, 32.4% and 33.3% for M1, M2, M3 and M4 respectively. This increasing can be explained to the contribution of the existing MWF which has the ability to improve the load-bearing capacity in the post-cracking zone, and limit the crack proceeding [23].

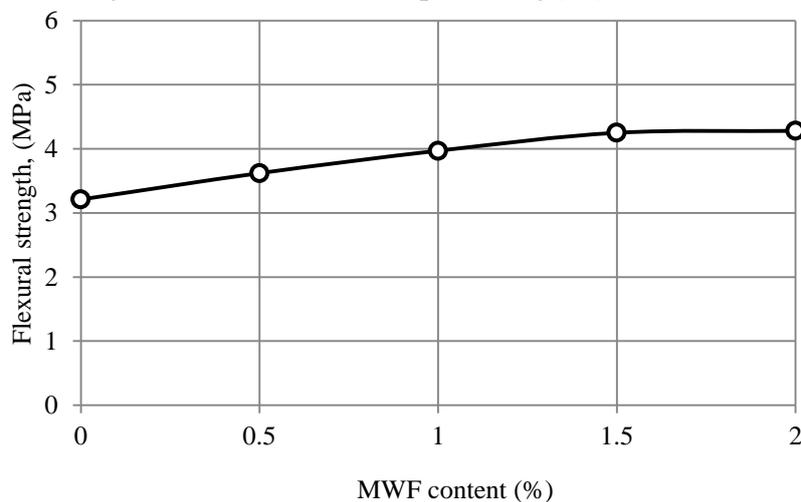


Figure 7. Effect of metal wastes fibers content on flexural strength

4. Conclusions

Based on the results obtained from this study, the following conclusions were made:

- Using of metal wastes fibers in concrete is an effective parameter to enhance the mechanical properties of concrete with an economical method, also to limit the solid wastes quantities.

- Slump value of concrete mixture reduces with increasing of metal wastes fibers content, more than proportion 2% make workability of concrete so difficult.
- The optimum proportion of metal wastes fibers requirement for compressive strength improvement is about 1.0% by volume of concrete, and 1.5-2.0% for splitting tensile and flexural strengths.

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