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The Utilisation of Lathe Steel Waste Fibers to Improve Plain Concrete

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***Abstract*—We studied the effects of using industrial steel solid wastes resulted from lathes to enhance the compressive strength of concrete.**

In average, 3-4 Kg/lathe of steel waste fibers are produced on daily basis. Such steel waste can be recycled in order to mitigate its environmental hazards. Moreover, using it to reinforce concrete is a feasible and sustainable solution. Six (6) concrete cube specimens were casted with (1% and 2%, in terms of concrete weight) and without steel waste then tested under compression. Also, the workability of the casted fresh concrete with different ratios of steel waste (0%, 1%, and 2%) was estimated utilizing the slump test.

The results shows that adding lathes steel waste fibers to plain concrete enhances its compressive strength while the workability of the fresh concrete containing the steel waste fibers decreases.

Keywords— Steel Waste Fibers, Steel Lathes, Compression, Workability, Slump Test.

I. Introduction

Steel waste fibers are generated with large amounts each day, which represents an environmental challenge. Recycling solutions of such a solid waste by using it to enhance the strength of concrete is a sustainable solution.

Fiber reinforced concrete (FRC) is a material composed of hydraulic cement, sand, coarse aggregate, water and randomly distributed short discrete fibers. The strength of such a material surpasses that of plain concrete and other construction materials of equal cost. Hence, FRC has been widely used in airport and highway pavements, earthquake-resistant structures, … etc. [1].

For M5 to M25 grades (M is mix proportion, 25 the strength concrete reaches after 28 days 25 N/mm²) [2], the one can determine the mix proportions ratio of concrete ingredients adopting the standard ratios (nominal mix concrete), while for higher ratios and strengths, the one must design the concrete mix proportions depending on the desired strength, admixtures, steel waste fiber and workability condition. For the mix design of M40 grade, which is the targeted grade, the mix design depends on the data required:

1. Strength for the mix design;
2. W/C ratio;
3. Estimated entrapped air.

Cube specimens of concrete are casted, then these specimens will be tested after 7, 14 and 28 days [3]. The compression strength obtained from the compression test must equal the targeted strength. Moreover, we can add the required amount of waste steel that enhances the mix properties obtained.

II. Material Description

The materials used in this study, e.g. steel waste fiber, cement, aggregates, water, … etc., will be thoroughly explained.

A. *Cement*

In this research, the most common and widely used Ordinary Portland Cement (OPC) has been used.

B. *Aggregate*

The sieve No. 4 (4.75 mm) is the limit between the fine and coarse aggregates (see Figure **2**), where the former aggregate, including the sand, is the soil passing from this threshold sieve and the latter is the retained soil [4].

C. *Water*

The available tab water that meets the requirements of water for concreting and curing according the specification of water reported by the American Society for Testing and Materials (ASTM) C 94 [5] has been used.

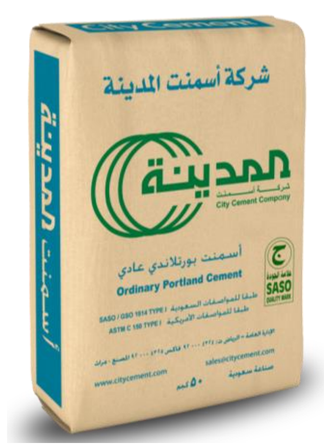

Figure 1: The “City” Ordinary Portland Cement.

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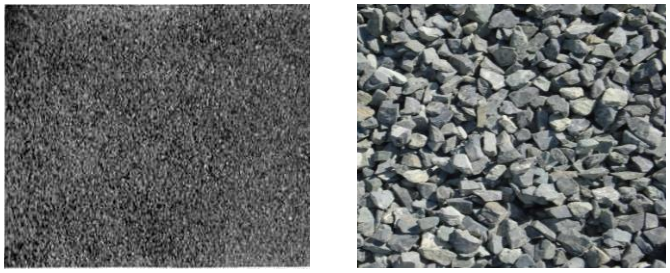

Figure 2: The fine (left panel) and coarse (right panel) aggregates.

D. *Steel Waste Fiber*

The industrial steel solid wastes resulted from lathes as fibers, see Figure **3**, have been utilized to prevent both the steel waste fibers from balling and the concrete from cracking and segregation.

The waste steel must be well-distributed during the mixing in order to prevent segregation or balling of the fibers during mixing, therefore, the steel fibers were added in the beginning of the mixing process.

The hooked-end steel waste fibers have been added, in terms of volume, with percent ratio equivalent to 1% to 2% of the total concrete volume.

III. Design Mix

In this study work, two concrete specimens were casted for each design mix, i.e. 0, 1, and 2 % added-waste steel fibers, to have a total number of six (6) concrete specimens. The first specimens coincides with 0% of waste steel fiber, the second was mixed with 1%, equivalent to 420g, of the waste steel fiber, and the last specimen has a content of 2%, which equals 840g in terms of weight, of waste steel fiber.

The mixing process is summarized in Figure **4**. Each specimen was made on 3 layers, where is each layer was compacted using a 380 mm long steel bar that weighs 1.8 kg and a 25 mm square end for ramming. Each layer received a minimum of 35 uniformly distributed strokes [6].

Figure 3: The hooked-end industrial steel solid wastes.

The concrete specimens were weighted immediately after casting and after Twenty-four (24) hours then they were cured for Twenty-Eight (28) days. After that the compression test was carried out according to the Saudi Building Code (SBC) [2].

IV. Results and Discussion

In the sequel subsections, the results of lab tests are reported and discussed.

A. *Slump test*

The results of the slump test carried out using fresh concrete samples for the plain concrete and concrete containing waste steel fibers, i.e. 1% and 2 % in terms of total volume of the concrete, are summarized in Table **1**.

The slump values were 100 mm for the plain concrete sample with no added-waste steel fibers. The slump value dropped to 75 mm when 1% waste steel fibers was used, and 60 mm for the 2% added waste steel fibers, respectively.

Such results could be attributed to the higher interlock among the steel fiber waste during the mixing resulted by the increasing percentage of the added steel fiber waste.

B. *Compression test*

Table **2** document the results of the compression test (Figure **5**) carried out for the casted and cured concrete cube specimens with and without adding the waste steel fibers

A) The plain concrete is casted

B) The steel fibers are added to the plain concrete

C) The cylinder/cubic molds were used and the concrete specimens were casted on 3 layers

D) The casted concrete specimens are cured for 28 days

Figure 4: The mixing process.

Table 1: The slump test results of the casted samples containing different ratios of waste steel fiber.

Sample [% Steel Fibers]	***Slump [mm]***
First [0%]	100
Second [1%]	75
Third [2%]	60

It is clear that the addition of the waste steel fibers to plain concrete enhances its compressive strength. The increasing in strength achieved by adding waste fibers (1%, 2%) This indicates that the strength of concrete increase markedly under compression. This may be attributed to increase the bonding among the concrete compounds (concrete reinforcement).

Table 2: The weight and compressive strength of the casted samples containing different ratios of waste steel fiber.

Sample [% Steel Fibers]	***Cylinder Weight [kg]***	***Compressive Strength [kg/cm²]***
First [0%]	12.13	216.8
Second [1%]	12.67	249.8
Third [2%]	13.21	245.2

I. Conclusion

On the one hand, the addition of steel waste steel fiber lathes to plain concrete enhances its compressive strength.

On the other hand, adding steel waste fibers reduces the workability of fresh concrete.

Exploiting the industrial steel waste in improving the casted concrete, in terms of compressive strength, is an environmental-friendly use of steel lathes since a large quantity of is generated from industrial lathes (3-4 kg/lathe/day).

A) Plain concrete (0% added waste steel fiber)

B) Plain concrete (1% added waste steel fiber)

C) Plain concrete (2% added waste steel fiber)

Figure 5: The Compression test of the concrete specimens casted with and without adding waste steel fiber.

The recycling of these steel wastes in construction and concrete production businesses represents a sustainable solution by creating a positive impact from using it stead of dumping in and generate environmental hazards.

Acknowledgment

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